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Forthcoming Events.

Institute of British Foundrymen.
JANUARY 4.
Lancashire Branch:—Ordinary meeting at Manchester. "Aluminium," Paper by N. C. Ashton.
West Riding of Yorkshire Branch:—Ordinary meeting at Bradford. "The Influence of Manganese on Cast Iron," Paper by H. Forrest.

Retrospective 1929.

This year has witnessed the furtherance of international amity amongst foundrymen by the holding of the Third Triennial Congress in London last June. It was attended by representatives from every European country, the United States of America, and Mr. Mason, who represented his Government, travelled from Australia. In September the German Ironfoundry Employers' Federation organised a national exhibition. Because of their desire not to damage the interests of the British effort, their action in delaying invitations until after the International Congress has been misunderstood in certain Continental countries. Trade has improved throughout Europe during the year, but there has been a general increase in costs of labour and raw material. This particularly applies in Germany, Czecho-Slovakia and Belgium. In the last case the building of the palaces and other works for their International Exhibition at Liége and Antwerp to be held next year has created an acute labour shortage amongst the foundries. Early this year, under the energetic leadership of Mr. Paul Ropsy, the Belgian foundry owners have organised an Employers' Federation based on excellent precepts.

The Exhibition which the German foundry authorities organised was a magnificent enterprise, inasmuch as it showed the technical development of every phase of foundry activities. France during the past year has suffered a little from labour shortage, and this may in some degree be responsible for the serious effort the industry has made in continuous-production methods.

Trading conditions in the British foundry industry have been wonderfully good, considering that it has had to withstand the disturbances caused by the General Election, the Hatry crash and the general rise in the cost of raw materials. When the year opened, No. 3 Cleveland was costing 66s. per ton. There were increases in February, April, May and June, since when it has been impossible (except through merchants who had covered themselves earlier) to buy under 72s. 6d. Coke is probably, taking the country as a whole, 5s. a ton dearer, whilst scrap, though in recent weeks easier, is, on the whole, several shillings a ton more expensive.

The agricultural implement foundries have done infinitely better during the past year. The A.E.G. has recently been particularly energetic and has created a mondial sales organisation, whilst Listers, of Dursley, are preparing an ambitious extension scheme. The electrical foundries, too, have, on the whole, done extremely well. One of the largest is now employing more men than at any period since the post-war boom. At the moment one of them is a little short of work on the heavy side, but it is really an exception.

The shipbuilding returns for the first half-year were of an imposing magnitude, and obviously the foundries attached to the industry were kept fully employed. Since June, however, the industry has been patchy, some districts being on full time, whilst others languish.

The large pipe foundries have more than maintained the 1928 output, but probably at decreased prices. Exports to the end of November are 22,000 tons, or over 20 per cent., higher than last year, the Argentine Republic being responsible for 14,000 tons of this increased demand. The average price, unfortunately, has declined from £11 14s. to £10 12s. Last year we reported a 9 per cent. decrease, with a 2s. per ton fall in price.

The automobile foundries have maintained an even keel. The Morris concern has created a continuous casting foundry embodying the latest features in materials handling, whilst the Birmingham Aluminium Company, the Midland Motor Cylinder Company and Sterling Metals have joined forces and now represent one of the largest foundry groups of Europe.

The light-casting industry has had a particularly interesting year. A new foundry was started for making bath tubs at Greenford, on the outskirts of London; a foundry for soil pipes was commissioned at Welwyn; whilst one of the largest Falkirk foundries finished its ambitious programme of extensions. During the year a serious effort was made to create an association for the industry to replace the National Light Castings Association. Several meetings were held, with Sir G. Rentoul as advisor. The whole effort has been abortive, and the conduct of the industry's commercial activities is still effected through the old organisation. The Scottish Section has recently been buying both Continental and Indian pig-iron instead of Cleveland. This section started the year with a labour dispute, which was settled in February by the moulders accepting a 5 per cent. reduction in two stages. The export trade has done better than the previous year. Not only has 1,200 tons more than in 1928 been exported, but in general a slightly higher price has been received. The average price last year was £44 16s., whilst this year it reached £45 2s. 6d. It should be borne in mind, however, that the average suffered a reduction of £1 9s. in 1928. It is interesting to state that the quantity and value of exported builders' castings in the month of November was a record for the last two years. Actually, up to the end of November 18,498 tons were sent abroad, as against 17,269 tons in 1928. This section, too, has had its grouping, and early in the year Allied Ironfounders, Limited, was formed, which controls a matter of a dozen foundries. As to the other sections of the ironfoundry industry—the railway, textile and printers—little change in business conditions is to be noted.

The technical side of the industry continues to progress rapidly. The Institute of British Foundrymen, under the excellent leadership of Mr. Wesley Lambert, has made material progress. Mr. T. Makemson, the secretary, informs

us that the position of both membership and finance is making steady progress. The International Congress, which it organised, has been the subject of enthusiastic eulogies from all who had the privilege of participating.

The question of education has been actively taken up by the Institute of British Foundrymen, and, while it would be unwise at this stage to disclose the nature of negotiations still proceeding, it is believed that active progress is being made in directions which will command the hearty support of the trade as a whole.

The Foundry Equipment and Supplies Association, under the chairmanship of Mr. H. Winterton, has had a particularly strenuous year. To its Council and honorary secretary, Mr. Kenneth Bridges, fell the lot of organising the International Exhibition. The Council was extremely fortunate in being able to enlist the services of a representative and extremely erudite sub-committee for the organisation of the technical and educational exhibit. Under the inspiring leadership of Dr. W. Rosenhain, F.R.S., a comprehensive exhibit was formed which demonstrated just what scientific research was doing and could do for the foundry industry.

The malleable foundry industry of Great Britain is a mixture of the modern and ancient. The foundries entering into the former category are extremely progressive, and the developments they have effected in recent years, especially in the application of powdered fuel, are worthy of emulation by other sections of the industry. They have been kept fully employed throughout the year, except for a slight depression in the early summer. Conditions are so good now that extensions are being contemplated by one of the largest concerns.

The steel foundry industry, too, is making real progress. During the lean years which followed the war a large number of steel foundries went out of business. This year the industry has doubled its all too meagre exports, but it is a good sign. An effort is being made to form an employers' federation, and we wish the supporters every success in their endeavour.

The non-ferrous foundry industry is such an amorphous affair that it is difficult to appraise reasonably its activities. We have visited a number of such foundries during the year, and where good metallurgical control and a specialised business are combined, there we find industrial activity. The non-ferrous raw material market conditions for 1929 will be dealt with early in the New Year.

Turning to technical developments during the period under review, it may be said that one of the most important events of the year has been the formation of the Iron and Steel Industrial Research Council. This may in a sense be regarded as a Research Association for the heavy iron and steel industry. It is sponsored by the National Federation of Iron and Steel Manufacturers, and it will work in close co-operation with the Cast Iron Research Association. The Council proposes, however, to confine itself to problems relating to the practical side of the industries concerned—problems of open-hearth melting, blast-furnace practice, the rolling-mill, etc.—in preference to undertaking more academic research, and its work is bound to have important repercussions on the foundry trade.

So far as the work of the Cast Iron Research Association is concerned, it is evident, first and foremost, that marked progress has been made in the matter of heat-resisting irons. Those who read our report of Dr. F. E. Smith's remarks at the Association's annual meeting will recall that some retorts for low-temperature carbonisation installed to a design and composition suggested by the Association—which have, incidentally, to work perpetually at a temperature well over red heat—have shown, after fourteen months' working, less growth and distortion than any previously installed retorts in the experience of the Fuel Research Board. Recent laboratory work promises, we understand, further developments.

Some remarkable results have been obtained in the direction of economical cupola melting—the figures for coke consumption having been reduced below 6 per cent. We would deprecate the tendency among founders to compare cupola performance exclusively on a basis of coke consumption—irrespective, that is, of length of run, size of scrap, composition of pig-iron, etc.—but, even so, this figure may be taken to indicate very marked progress. Other technical developments cover progress in the correlation of various forms of mechanical tests one with another, and the strength of a cast-iron section with its size; moulding sands and their practical foundry control; alloy cast irons, particularly those containing nickel and chromium; the relationship between structure and composition; changes that take place on cooling, with resultant differences in structure even with the same composition.

Alloyed, especially nickel, cast iron is finding favour, and has definitely found for itself a niche in the industry. The various high-duty irons are making rapid progress, as the engineer-buyers are gradually appreciating their significance. There has been a real impetus towards the mechanisation of foundries, and only a week or two ago Mr. Beech reported that he had prepared no less than 30 schemes for modernising foundries. In the automobile industry there is movement towards the insertion of liners into cylinder blocks, these liners consisting of very high-grade cast iron—some may be spun or may contain alloys and be heat-treated to give an excellent wearing surface. A Continental development is the washing of castings to replace the normal fettling-shop methods. In this country, however, the sales of modern sand-blast plant are rapidly increasing, and no wet-cleaning installation has yet been made.

In general, so far as the British foundry industry is concerned, it can look back on 1929 as being a year of good progress.

Reports and Dividends.

North Lonsdale Iron & Steel Company, Limited.—Net profit, £3,998; brought in, £10,444; carried forward, £14,443.

Atlas Steel Foundry & Engineering Company, Limited.—Profit, £6,445; to reserve, £3,000; to depreciation, £3,000.

Boulton & Paul, Limited.—Net profit, £31,531; brought in, £21,165; dividend of 5 per cent.; to reserve, £10,000; taxation reserve, £7,000; carried forward, £23,639.

Stewarts & Lloyds of South Africa, Limited.—Profit for nine months to June 30, £29,508; brought in, £7,334; depreciation, £8,075; carried forward, after providing for preference dividends, £2,141.

Crittall Manufacturing Company, Limited.—Profit, £240,651; brought in, £10,036; balance of share premium account, £168,947; to reserve, £150,000; depreciation reserve, £50,000; dividend of 10 per cent. on the ordinary shares; carried forward, £6,376.

Redpath, Brown & Company, Limited.—Net profit, £117,972; brought in, £46,291; distribution for the year on the ordinary shares of 22 per cent., tax free, including a bonus of 6 per cent.; to reserve, £25,000; staff pension scheme, £5,000; carried forward, £46,763.

The London and North Eastern Railway have placed contracts with the following firms for 47,000 tons of steel rails: Barrow Hematite Steel Company, Limited; Shelton Iron, Steel & Coal Company, Limited, Stoke-on-Trent; English Steel Corporation, Limited, Sheffield; Samuel Fox & Company, Limited, Sheffield; Dorman, Long & Company, Limited, Middlesbrough; Pease & Partners, Limited, Saltburn; Bolckow, Vaughan & Company, Limited, Middlesbrough; Cargo Fleet Iron Company, Limited, Middlesbrough, and Steel Company of Scotland, Limited, Glasgow.

Random Shots.

Talking a week ago of my inability to be in more than one place at once, I am reminded of the writer—or writers—of a not altogether dissimilar feature in an altogether dissimilar journal. Apparently his readers spent so much time and energy—his as well as their own—endeavouring to penetrate the veil of anonymity that surrounded him, that he ultimately announced himself to be not an individual, but a group, and thenceforward referred to himself and signed himself in the plural! Actually it had been fairly clear for some time to the attentive reader that more than one hand was at work—unless one supposed the individual concerned to be capable of writing in at least three different styles and to be also an expert on music, the drama, nature study, travel, suburban life, and a vast number of other matters. But let me deny the soft impeachment. "Marksman" isn't a syndicate. I don't pretend to invent all the stories I tell, and I am always delighted to receive correspondence and to quote it when appropriate. But beyond that the credit, or the discredit, as you may consider, are alike my own.

* * *

When I wrote about personalities in the foundry trade, I was thinking how interesting it would be were it possible to obtain a vote as to the six—shall we say—outstanding characters in our midst. No, I'm not proposing to act on the thought; it wouldn't be safe, or fair either. But up to a point I suppose most of us would agree. Beyond that point the difficulty would begin. You can interpret that whichever way you please—to mean equally that it would be difficult to limit the list to six or that it would be difficult to find more than six. But it would be extremely interesting to see how far we were all agreed as to the leading figures of the trade.

* * *

Broadly speaking, past-presidents of the I.B.F. would figure largely in any such list, since their election to office is in some sense a recognition of the very qualities that I have in mind. In some quarters, I admit, there is a tendency for a man to drop his interest in an institution after he has "passed the chair," and thereby to forfeit no small part of the esteem and affection to which he would otherwise be entitled. But far be it from me to suggest that anything of the kind happens among foundrymen! Branch presidents might be included for similar reasons. Beyond these distinguished ranks, I think most of us have an especially soft spot in our hearts for the men who are good company; the men who make good speeches and tell good yarns; the men who appreciate that "all work and no play make Jack a dull boy."

* * *

Yet my own wide acquaintance in foundry circles convinces me that there is no room in our midst for the spurious good fellow; he must be genuine above all things. Founders are as shrewd as most men, and a bit shrewder, and if it *were* possible to take seriously such a vote as I have suggested in all lightheartedness, I have no doubt that the leading half-dozen would be men of the type who really form the backbone of British industry.

* * *

I seem to have borrowed some of the Editor's thunder this week and become quite unnecessarily solemn. Please put it down to a combination of Christmas pudding past and New Year resolutions to come, and pity poor

Marksman.

Metal Melting by Electricity.*

By D. F. Campbell, M.A., and W. S. Gifford.

The commercial electric melting of metals in Great Britain was begun in 1909, when arc furnaces were started in Edgar Allen's works, in Sheffield, for the manufacture of tool steel, and at Lake & Elliot's foundry, at Braintree, for steel castings. It was not proposed to carry the subject back further to the early development of electric furnaces in France, Sweden and elsewhere, but preferably to deal with the different types of electric furnaces which have been developed for various metal-melting operations, giving detailed accounts only of those of each type which have proved the most successful.

The melting and refining of steel is the most extensive application of electric melting, excluding the electrolysis of fused alumina for the manufacture of aluminium, the tonnage of electric steel produced throughout the world being now about 1,500,000 tons. The electric furnace is especially favourable for alloy steels, the demand for which is steadily increasing. Until last year almost the whole of this tonnage was produced in arc furnaces, the majority of which are of the type introduced by Dr. Héroult in 1906.

Arc Furnaces.

The arc furnace is well known, consisting of electrodes suspended above the bath, and characterised by an intense local heating on the slag surface by the arc, which is at a temperature of about 2,500 to 3,000 deg. C. This intense temperature has disadvantages, especially if volatile metals are present, and hence arc furnaces have principally been applied to the melting of iron, steel and nickel. In the steel trade, basic-lined furnaces, with dolomite or magnesite linings and silica roofs, are used for refining operations, carbon and phosphorus being removed with an oxidising slag of iron ore and lime, while the finishing operation of desulphurising and deoxidising the steel is performed with a lime-fluorspar slag. Acid-lined furnaces, having a siliceous hearth and roof, are also used for simple melting operations.

Recent modifications in furnace design are few, the basic features of Héroult's original furnaces being closely followed. Increased power and more rapid melting are common features of modern installations, and a reduction in labour costs results, though the unit consumption is but little improved and excessive speed is undesirable for certain complex alloy steels.

Economy in Foundry Floor Space.

In foundries, small rapid melting units are especially advantageous, as excessive refining is unnecessary, foundry floor space is economised by a rapid succession of small heats and the high temperatures required can be reached. These features are, however, also obtainable with basic-lined high-frequency furnaces, which will be described later, and the improvements made in the performance of the high-frequency furnace during the last few months will make it a severe competitor of the small high-powered arc furnace for foundry work.

Improvements of automatic regulators during the last ten years have been very marked, and no hand regulation is now necessary when melting cold scrap, as the newer type of regulator can take care of all violent fluctuations of current, even when full load is put on a furnace melting heavy scrap. The advantage of maintaining full load from the start of melting is reflected in a marked improvement in the unit consumption per ton melted.

* A Paper read before the joint meeting of the London Sections of the Institute of British Foundrymen and the Institute of Metals, Dr. Smith presiding.

Little Progress in Iron Foundries.

The melting, refining, mixing and superheating of cast iron in electric furnaces has not received the attention in Great Britain which it deserves. One reason, perhaps, is the excellent supply of special qualities of cast iron available in the country, but it must be recognised that our old and important export business in special irons to France and other Continental countries has been hard hit by the production of so-called synthetic irons and the refining and mixing of common irons in electric furnaces. The direct manufacture of special cast iron from ore is only of academic interest to British manufacturers, as it cannot be practised in this country. Excellent iron, however, is being produced in countries specially favoured by cheap water-power and penalised by the absence of good coal. Such an iron produced in Norway has the following analysis:—

	Standard.	Refined.
Total C	4.0 to 4.5	2.5 to 3.5
Si	0.5 to 1.5	1.70 to 2.5
Mn	0.20	0.20
S	Trace	Trace
P	0.20	0.15 to 0.20
V	0.20 to 0.30	0.20 to 0.30
Ti	0.30 to 0.50	0.30 to 0.50

The authors would, however, be deeply interested in the production of special quality and alloy cast iron in the electric furnace, owing to the wide application of this method in the U.S.A. and almost every Continental country where high-duty cast iron is required. In Germany, France, Sweden, Switzerland, Czecho-Slovakia and Austria many foundries are casting regularly and extensively cylinders, Diesel-engine parts, machine castings of all sorts, of easy machinability and high physical properties, but in this country there are unfortunately but one or two furnaces used for such work.

The process used is either to melt cold stock in the electric furnace, or to transfer molten metal to a basic arc furnace and refine, add or adjust the alloys, and then superheat to any required degree, and cast the metal of a definite known composition at the required temperature. This cannot be done in a cupola. Electric-furnace iron has a definite, known composition and heat; impurities can be removed, and absolute homogeneity obtained. Cheaper iron or scrap of unknown composition can be used, and a bath sample tested, so that a considerable saving in the cost of raw material can often be realised.

Electric Furnace and Nickel Additions.

The greatly increased use of nickel and chromium and other metals alloyed with cast iron requires such accurate methods of work and superheat to obtain true homogeneity

In the cupola, with a maximum temperature of about 1,450 deg., uniformity of composition throughout the metal cannot be obtained with refractory metals, and the impurities from the coke and gas are one of the principal causes of poor results in iron castings. The best quality of cast iron is made by melting in an arc furnace high-class steel sheet scrap, such as dynamo sheets, with pure carbon, such as petroleum coke, in a sealed furnace which should be kept closed until the charge is molten. This method avoids any contamination by S, P, Sb, As, or other impurities, but must be considered an expensive method of producing the highest quality of iron. For general purposes a very high-grade iron may be made either by melting iron scrap or borings, or charging liquid metal from a cupola, and subsequently refining the bath by the usual methods with lime slags. Additions of other metals or silicon, etc., may be made under complete control and any required degree of superheat obtained.

Fine Graphite Structure.

This is not the place to enter into discussions of the effect of hot moulds on the structure of iron castings, but the importance of absolute control of casting temperatures and its influence on the structure of the iron produced and on the temperature of mould required, will be readily appreciated. The even distribution of the graphite in electrically-melted iron results in remarkably fine results on impact tests, which are quite unobtainable with cupola metal. A very characteristic feature of electric cast iron is its softness as compared with a cupola iron giving the same tensile strength, hence its high degree of machinability. The high polish which can be obtained is similar to that of steel, a fact which is to be attributed to the fine subdivision of the graphite. The even nature of the metal makes it especially suitable for high-temperature work, such as the construction of internal combustion engines, superheated steam turbines and similar applications.

Superheated Electric Cast Iron.

Large quantities of castings and so-called semi-steel are produced on the Continent from electric furnaces, and the metal is much quieter than metal of corresponding composition from a cupola. Many changes in foundry practice can be made with electric furnaces. Thus, for example, if cupola metal be used, a certain percentage of silicon and a mould at, say, 120 deg. C. may be necessary to get a given result, but if the iron be superheated from 1,450 to 1,650 deg. C., the same result may be obtained in a green-sand mould with less silicon. Thus lower carbon and silicon can be used, which gives greater resistance to corrosion and a better structure. Thinner sections may be used, especially for heat-resisting and chemical castings, and this saving in weight may be sufficient to pay the extra cost of electric refining, if this is not already covered by saving in the cost of raw materials.

Steel Castings.

The manufacture of steel castings from electric furnaces has assumed very large proportions in the United States of America, the output being now about 350,000 tons per annum. Small castings are now almost exclusively made by electric furnaces or Tropoenas converters. The former use steel scrap and involve a loss of about 6 per cent. in melting, and the latter hematite pig-iron and lose from 15 to 19 per cent. in the blowing operation. The relative merits of the two processes depend largely on the prices of hematite iron, on one side, and steel scrap and electricity, on the other. The small converter is easy to start and stop, and the metal is characterised by the property of keeping hot a long time in the ladle, probably due to the continuance of exothermic reactions in the ladle. The metal is not so good as that produced in the electric furnace, and the impurities in the pig-iron are increased by the impurities in the coke, whereas in the electric furnace complete refining can be effected, if a basic furnace is used. If good scrap is available, the cheapest steel will be made by melting on an acid bottom in small high-powered furnaces.

Relative Cost of Tropoenas and Electric Steel.

The following figures, taken from the operation of a 3½-ton Héroult electric furnace and a Tropoenas plant, may be of interest. They are for carbon steel:—

	Tropoenas.	Héroult.
Loss	19.2%	3.2%
Iron or scrap ..	£5 3 7 per ton	£2 16 6
Melting cost ..	£1 18 7	£5 0 5
Total	£7 2 2	£7 16 11

The Héroult furnace-melting cost includes an item of 11s. 3d. for electrodes and 737 units

of electricity, costing 36s. 9d. With the high-frequency furnace, electrodes are not used and a lower power consumption is required, and the cost of labour is substantially reduced. Consequently, the cost of liquid steel is very near to that of the converter, if a large unit is worked to maximum output. To obtain the full benefit of the high-frequency furnace when making steel castings, re-organisation of foundry methods, so that the moulds may be cast directly from the furnace, is advantageous.

In one foundry, casting motor-car castings averaging about 2½ lbs., the time taken for casting from hand shanks was at least half the time taken to prepare the moulds. By the use of nose-tilting high-frequency furnaces melting a charge every 50 to 60 min., the moulds may be cast direct on a conveyor, labour and floor spaced saved and the cost of production reduced. The direct method of casting avoids the necessity of superheating, to allow for the inevitable heat losses which occur in hand shanks.

Non-Ferrous Melting.

The melting of brass by electricity was first practised in furnaces of the indirect arc-type, generally having horizontal electrodes and a barrel-shaped body, which was rocked or rotated. A large number of these furnaces were installed in the United States, but none has been regularly worked in Great Britain. The excessive temperature of the arc is not necessary for brass melting, and is objectionable owing to the volatilisation of zinc. The furnace can be intermittently worked, which accounts for its wide application in brass-sand foundries as opposed to ingot-casting shops, where induction furnaces are generally preferred for many reasons. In England, many brass-sand-casting foundries work intermittently and require castings of great variety, so that the comparatively high capital expenditure for electric furnaces prevents their wide application in these foundries, while the large units required for heavy marine castings favour the use of reverberatory furnaces, which involve lower capital expenditure. It is interesting to note, however, that there are now 50 Ajax-Wyatt furnaces in the U.S.A., working in sand foundries, operating only one nine-hour shift per day.

In all cases, however, where brass is being melted for rolling-mill work, the induction furnace should be used, provided the output is sufficient to justify the installation of a 40- or 60-kw. unit, that is, a furnace melting 4 to 6 cwts. per hour.

The furnace most generally adopted is the Ajax-Wyatt, of which there are about fifty-three 6-cwt. units, two 12-cwt. furnaces and three of 22-cwt. in operation or construction in Great Britain. These represent an output of about 100,000 tons per annum. When these furnaces are in continuous operation the cost of the plant is paid for in saving of manufacturing costs in 12 to 24 months, under conditions such as those at Birmingham. The following figures relating to the production of a new shop equipped with a number of these furnaces and another working with the old crucible process may be of interest:—

	New.	Old.	Saving.
Labour	14/9	21/8	6/11
Crucibles or lining ..	1/6	4/6	3/–
			Loss
Coke and power	8/11	7/-	1/11
Metal loss			15/–
	Total saving		23/–

that is a saving of about £1,750 per annum per 60-kw. furnace. The three Ajax-Wyatt furnaces, of 22 cwts. capacity, now being constructed in England, are the largest units of this type of furnace yet designed.

Induction Furnaces and Low Current Consumption.

The induction furnace most commonly used has an iron core and a secondary channel totally submerged. Heat is generated in the metal itself and no part of the furnace is hotter than the metal in the secondary. Thus any objectionable superheating is avoided and the ideal method of heating is obtained. This furnace is probably the most efficient appliance used for metal melting, as the furnace transformer has a loss of only a few per cent. and the thermal efficiency is high. For these reasons the power consumption per ton of brass melted is very much lower than with arc furnaces and the metal loss due to volatilisation of zinc is also very low. A series of 6-cwt. furnaces operating over a number of months will give a power consumption of less than 215 units per ton of ingots, while furnaces of double this capacity will consume about 190 to 195 units per ton of 60/40 brass melted. Until recently the use of the Ajax-Wyatt furnace was limited to brass owing to difficulties in furnace linings, but now refractories and methods of fritting linings have widened the field of these furnaces so that nickel-silver, manganese bronzes, high copper alloys and pure copper can be economically melted. This is the most important development of the last few years in non-ferrous metal melting.

Induction-furnace linings may be made in four different ways: by ramming a specially-prepared cement damped with silicate of soda, by building it with air-dried blocks, by constructing it of prefired bricks and blocks of special form, or by the Rohn process of fritting dry-powdered linings. The last named is an interesting method.

The Rohn Process.

A secondary former is built up by welded sheets or bars of a metal such as nickel or steel, which can be heated by induction or resistance to a temperature at which the refractory material will frit. The lining material, which has been poured round the former in the dry state, is glazed on the surface and a very satisfactory lining can thus be made. This method is usually used for furnaces for nickel-silver, phosphor-bronze, cupro-manganese, copper and other higher melting-point alloys.

High-Frequency Furnaces.

The most modern development in metal melting by electricity and one of exceptional interest, is the Ajax-Northrup high-frequency furnace. Heat is generated within the metal itself as in the Ajax-Wyatt furnace, but the form of the bath in this ironless induction furnace is exceptionally favourable for metallurgical operations, as the heat is well controlled and the thermal efficiency is very high. The development of the high-frequency, or rather, the ironless induction, type of furnace has been marked by three stages. In the first stage, the furnace was used simply for laboratory purposes or for melting a few metals commercially in small quantities. During this stage the high-frequency current was obtained by means of a spark gap and condensers, which necessarily limited its capacity. The largest spark-equipment was capable of an output of about 20 kw., which was sufficient for a furnace holding about 20 lbs. of steel, though in one case where larger ingots were required, two or three generating equipments were used together on one furnace, so that about 50 lbs. could be melted. These equipments were necessarily expensive, and, though of great value for research and for melting metals where a very high degree of purity was essential and cost a matter of relatively small importance, there was obviously no great scope for commercial development.

In the next stage, motor generator equipments were developed to produce moderately high frequency currents, and furnaces installed of about 150-kw. capacity, melting up to 5 cwts. of steel in an hour. It was immediately realised that this type of furnace was a serious menace to the crucible process in any steelworks where the output was sufficiently large to justify its installation. The furnace gave the tool-steel maker exactly what he had been wanting for years. It had all the advantages of the crucible process with several additional good points. It was considerably cheaper to work, labour was greatly reduced, and the heavy work necessitated in lifting and pouring crucibles was avoided. There was also a complete absence of sulphur fumes, which are inseparable from any heating medium other than electricity, and the metal was thoroughly stirred by electrical effects.

In a very short time after the first furnace was in commercial operation, over 20 plants were in operation in England and France alone. Most of these were used for steel-melting and the others for various alloys of nickel. These furnaces chiefly replaced crucibles, though in a few cases they were doing the work of small arc furnaces. The high-frequency furnace is finding a special application in the casting of stainless iron, as the possibility of carbon contamination from arc furnaces is avoided.

Relative Output of Various Types.

The next stage of development which is progressing rapidly is that in which the ironless induction furnace will compete with the small open-hearth and large arc furnace. At first sight it may appear that the capital cost of the plant will hamper any serious competition with furnaces of this type, but it must be remembered that melting is extraordinarily rapid and that a 2-ton ironless induction furnace is equivalent in output to an 8- to 10-ton arc furnace or a 20-ton open-hearth furnace. The actual furnace equipment may cost more than an open-hearth plant of the same daily output, but the costs of buildings, chimneys, cranes and annealing equipment, etc., are very much lower, and a complete new plant would probably cost considerably less than an open-hearth plant of similar weekly output. The relative cost of operation depends on a variety of factors, such as cost of power, etc. In England at present the acid open-hearth is probably several shillings per ton cheaper, but for many classes of steel the higher quality obtained in the coreless induction furnace is sufficient to justify the extra expense. In some countries, such as Sweden and Italy, where power is cheap, there is very little difference in the cost of working, and it is probable that those countries will be the first to take the next step. A furnace giving an output of 1 ton an hour has been in operation for some months, and a furnace of three or even five times the size presents no new technical problems comparable in difficulty with those which have already been successfully overcome.

The acid open-hearth process is, of course, necessary for many trades where large ingots are required for reaction chambers, high-pressure boilers, etc., and for tyres, where only large heats are used, owing to the methods of inspection. In the case of steels for magnets, motor cars, airplanes, manganese steels, and especially the heat and corrosion resisting group of alloy steels, the high-frequency furnace seems likely to replace the small acid open-hearth furnace. Arc-furnace working costs are considerably higher than those of high-frequency melting, though the capital expenditure of the latter equipment is considerably higher. A 10-cwt. high-frequency furnace will produce 10 tons of ingots per 24 hours, and a 2½- to 3-ton arc furnace is required for the same output. The cost of the former is about double that of the latter, and the interest and amortisation on the difference of price is about 2s. to 3s. per ton. The saving on electrodes alone is 8s. to 12s. per ton, and there is an additional saving in furnace repairs and labour because the charging is done by dropping the charge direct from a box hung from the crane, instead of charging everything with shovels through a door, with the risk of breaking electrodes during the operation.

Precious-Metal Melting.

The melting of precious metals by electricity is an important advance in the metallurgy of platinum and its associated metals, osmium, iridium and ruthenium. These can be conveniently melted in high-frequency furnaces, and the fusion of ruthenium powder in a vacuum is an achievement which has always presented great difficulty, owing to the readiness of this metal to combine with oxygen. By this means the fusion of tungsten has recently been accomplished at a temperature of over 3,500 deg. C. For the melting of silver the furnace has been used with success, the special advantage being the rapidity with which the furnace can be started when cold, and the freedom from masses of brickwork, coke and ashes, from which all precious metals must be recovered, when using fuel furnaces. The following results show the performance of a high-frequency furnace melting silver: The furnace used has a generator capacity of 150 kw., and heats of about 970 lbs. (12,000 ozs.) are made in 60 minutes, when starting with a cold furnace, and in about 47 minutes with a hot furnace. The production per kw.-hr. is 7.8 lbs. and 9.5 lbs. respectively. Small crucible furnaces for melting gold and silver heated by resistors are economically advantageous, owing to cleanliness and control.

The Problem of Aluminium.

The melting of aluminium by electricity is a problem which is constantly discussed. The reduction of the metal, of course, is always carried out in electric furnaces by the electrolysis of fused alumina with natural or artificial cryolite. The melting of scrap or the remelting of virgin ingot aluminium presents certain difficulties, as a very large amount of heat is necessary, although the temperature is low. The ready oxidation of aluminium, and the desirability of generally melting the metal in a state of tranquillity, are features which could be obtained in a resistance furnace, but, owing to the large number of heat units necessary, the operation is slow, because there is a limit to the amount of heat that can be produced by resistors of the ordinary metallic type, per unit of area, while the high-temperature resistors of the non-metallic carbon-silicon mixtures are expensive in maintenance and upkeep.

The high-frequency furnace is suitable for melting aluminium swarf, and super-heating liquid metal, with the object of alloying such metals as chromium, or other elements having high melting points, as a high degree of homogeneity is obtainable, and the temperature can be accurately controlled. Two examples may be taken—the melting of aluminium paper scrap, which is difficult by any other process, can be rapidly and fairly economically done in a high-frequency furnace, or an alloy of aluminium and chromium can be rapidly heated to 1,400 deg. or 1,500 deg., if desired.

The conditions in the high-frequency furnace are not, however, those of tranquillity, a desirable condition when dealing with aluminium alloys, and it is thought probable that the rapid melting in the high-frequency furnace would best be followed by treatment, for an hour or so, in a holding furnace maintained at 700 to 800 deg. resistors. Such furnaces, having capacities of 2 or 3 tons, are in use for the casting of slabs under absolute control of temperature and atmosphere. These furnaces may advantageously be used if the metal has been melted by any other process, or when it is charged in the liquid state direct from the reduction furnaces.

Die-Casting Pots.

Electrically-heated pots for die castings also present considerable advantages, as they can be placed at different points in the shop, without the necessity of any chimneys or flues, and the metal can be maintained at the required temperature constantly and regularly. The Ajax-Wyatt furnace has also been recently used for melting metallic zinc, as the very accurate control of temperature is advantageous when dealing with this volatile metal.

What is the impression of an electric melting shop as compared with the old crucible methods? In the first case, men working in ordinary clothes, quietly going about their work, watching their instruments, pouring their furnaces with a tramway controller, eating their lunch by their work, free from exhaustion and sweat. On the other side of the picture: In Sheffield, men with towels on their mouths to protect their lips, foreheads blistered with the heat, legs wrapped in dripping sacks, men of grand physique struggling and lifting heavy weights under appalling conditions, a fine study in strength and balance.

Or, again, in Birmingham: Less heat, but more "smother," zinc fumes and headache, loss to the master and nausea for the man. These conditions of work should not, and soon will not, be tolerated, as all these operations can be carried out with precision and under perfect control by electricity.

Industry is passing into an age of electricity. The largest brass works in Europe is now completing the final conversion of all heating and power appliances to electricity. Melting, reheating, annealing and drying are all electric. If the saving of metal losses, improvement of quality, conditions of labour, ease of control, reduction of waste, absence of fuel ashes, gases, smoke and chimneys are all taken into the reckoning, in many cases the application of electricity is fully justified, even where a superficial investigation may indicate that no direct saving will result.

Those who are in control of metallurgical establishments must face a few simple facts. Engineers are demanding more of the metallurgists' products. High working temperatures and pressures demand better cast iron for engine parts. Motor-cars and aeroplanes require better alloy steels and more accurate heat treatment. Brass must be capable of still deeper pressing and have a better surface. Condenser tubes of nickel-copper alloy must withstand corrosion. Stainless metals and electrical alloys must be melted without contamination by carbon, aluminium alloys maintained in tranquillity and poured at the correct temperature. These are the problems. Homogeneity of structure, control of temperature, elimination of impurities and regulation of furnace atmospheres are the solution, and the clue is electricity.

Contracts Open.

Earlestown, Lancs, January 6.—2,617 yds. of cast-iron pipes and three tons of standard specials, for the Newton-in-Makerfield Urban District Council. Mr. R. T. Surtees, engineer and manager, New Gasworks, Earlestown.

Johannesburg, January 30.—Pig-iron and ferro-manganese, for the South African Railways and Harbours. The Department of Overseas Trade. (Reference A.X. 8,915.)

London, S.E., January 13.—Iron and steel stores, for the Camberwell Borough Council. Mr. W. Bell, borough engineer and surveyor, Town Hall, Camberwell, London, S.E.5.

Preston, January 4.—Seven miles of 30-in. dia. steel water pipes, with bituminous lining and hessian cloth wrappings, for the Corporation. The Water Engineer, Tithebarn Street, Preston. (Fee £1 1s., returnable.)

Teneriffe, January 14.—Tramcars, rails and tramway equipment, for the Municipality of Teneriffe. The Department of Overseas Trade. (Reference A.X. 8,872.)

IN CONNECTION with the proposed fusion with Messrs. Henry Gardner & Company, Limited, the British Metal Corporation, Limited, propose to issue 100,000 ordinary shares to bring the capital up to £1,000,000, which is the same figure as that of Messrs. Henry Gardner & Company, Limited.

I.B.F. Branch Presidents—No. 4.

BIRMINGHAM BRANCH.

Mr. E. H. Tyson was apprenticed to pattern-making at the L. & N. W. Railway Carriage Works, Wolverton, and studied machine construction, chemistry and metallurgy at the Science and Art Institute at Wolverton. He was awarded the Queen's Prize for freehand drawing under the South Kensington Examination.

In the early days of the motor industry he joined the Great Horseless Carriage Works, Coventry; the Motor Manufacturing Company; Alfred Herbert, Limited, and the Rover Company. In 1898 he founded an aluminium and brass foundry at Coventry, known as Pearson & Tyson, where experiments were made in casting the lugs and bottom brackets on to steel bicycle frames in a light and malleable aluminium alloy known as "Romanium."

This firm made the patterns and castings for the first rotary engine for the inventor, Mr. Chubb, and also the patterns and castings for the first engine enclosed in a cycle wheel for Messrs. Pearks & Birch, of Coventry, which was later taken over by the Singer Company.

Mr. Tyson was next in business as master

MR. E. H. TYSON.

pattern-maker and constructed numerous experimental patterns for the British Motor Company for engines for the Bollie car. In 1912 he was appointed foreman pattern-maker at William Mills, Limited, Grove Street, Birmingham, and was promoted to works manager in 1917, retaining this position to-day.

During the war period, most of the first aero-engine patterns and castings for cylinders and cylinder-heads in iron and aluminium came under his control.

At this time Mills changed over their melting furnaces from coke to crude oil, and used the needle-point burner, but later were compelled to use the 50-50 per cent. crude oil and pitch. This was a continual source of trouble with choking burners, and Mr. Tyson therefore invented a type of burner which proved highly successful, and is still fitted to all the firm's furnaces.

He also made the gas-fired furnace burners, which are still being used at Mills.

He has been a member of the Institute of British Foundrymen since 1916, and a member of the Birmingham Branch Council for the past eight years.

XUM

Value of Research in Refractories.

DISCUSSION AT SHEFFIELD.

At a meeting of the Refractories Association of Great Britain, held at Sheffield on December 6, Mr. Frank West (President) in the chair, a general discussion took place on the "Value of Research in Refractories."

Col. Thomas, who was unable to be present, wrote that there was no industry in this country using heat treatment for any purpose which was not dependent to a greater or lesser extent on refractory materials for the efficiency of its work. If one considered those industries where heat was applied at considerable temperatures, for example, the production of iron and steel, it was at once evident that without reasonably good refractories the production of these metals and their manufacture into the various forms in which they were used to-day, would be quite impossible. If one considered the average life of any of the ordinary metallurgical furnaces, and the cost of labour and materials involved in the renewing of the refractory portion of the furnace when it was worn out, it was easy to prove that a moderate increase in the efficiency of the refractories used would make an enormous difference in the cost of furnace operation. Users were too prone to consider a slight difference in the first cost of refractory materials, and to ignore entirely the labour cost and loss of output which were involved every time that a furnace was shut down for repairs.

Central Fund for Research.

Continuing, the writer suggested that it would pay all those industries, where heat treatment at considerable temperatures was involved, to subscribe jointly the sum of from £10,000 to £15,000 per year, to be expended in extensive research into refractory materials, and the improved design of metallurgical furnaces in connection therewith. In a very few years the results obtained would be worth, to the industries concerned, many times the amount subscribed. So far, the manufacturers of refractories had shown a good deal of interest in research, but users had not shown very much, although it should be obvious that any benefits resulting from research would be to the advantage of users of refractories rather than to manufacturers of them.

Standard of Research.

The President expressed the opinion that business research to-day was a practical scientific process, which no progressive firm, much less a small progressive firm, could afford to ignore. One material might be refractory in one process but break down in another, and cases were known where the same refractory gave good results in the hands of one engineer, and bad results in the hands of another in the same works or in different works manufacturing the same products. The more modest but reliable refractory was the one with the longest life proportionate to the extra cost, and the production of such a material opened up a wide field for scientific research.

Iron and Steel Works Refractories.

Mr. W. J. Rees, dealing with the application of newer refractories to the iron and steel industries, said that there was a controversy which had not yet been settled, and did not appear likely to be settled within the near future, as to the relative merits of brick linings and rammed linings in the cupola. A good deal had been said, and could be said, as to the advantages of both types of linings, but the fact was that there was not sufficient information available as yet as to the characteristics necessary for good refractories to be able to settle the question definitely. The results up to the present were discordant, but they would need to be adequately collated, and there was need for a good deal of fundamental research as well as a good deal of applied technical research in this particular field.

With regard to the steel industry, the introduction of the high-frequency induction furnace was presenting problems in connection with refractories which were astonishingly different from those presented by almost any other use of refractories. In the high-frequency furnace there was a comparatively thin lining of refractory—2 in. or 3 in. at the most—which, on laborious for an organisation that had many the inner face, was exposed to the full melting temperature of the steel. On the other face, not more than 2 in. or 2½ in. away, the material was in contact with a water-cooled coil. There was a very steep heat gradient, therefore, on a very thin wall of material. A serious attempt was being made to supply refractories suitable for such a purpose, but the speaker was afraid that insufficient was known about the fundamental properties of some of the refractory materials to be able to apply them properly to such severe requirements.

What was wanted in the consideration of such a problem was both fundamental knowledge of refractory materials and continued experiments in connection with their application. It was an interesting new field of research, and it looked as though, within a few years from now, the crucible furnace as at present known, would have disappeared, or become almost a curiosity. The induction furnace was growing progressively in favour and popularity. During the past few months quite a number of additional furnaces of this newer type had been erected in Sheffield and elsewhere. Systematic investigations in such a direction could hardly fail to be of marked benefit to the metallurgical industries.

Basis of Working Conditions.

Mr. A. T. Green emphasised the fact that, in pursuing investigations into fundamental properties, a definition of the actual conditions obtaining in the use of refractory products was essential, and up to the present time this phase of the work had not received much attention. The fact that many apparently superior products had failed in specific duties, whereas the so-called inferior material had given comparative success in the same field of utility, had emphasised the need for the adequate definition of working conditions. It was evident that refractory materials were not yet amenable to very definite specifications, and endeavours to overcome this state of affairs should be made if the refractories industry was more accurately to meet its demands.

In considering refractories research in relation to the iron and steel and carbonising industries, it might be remarked that the formulation of a basis of open-hearth furnace design was a very confusing, though intriguing subject, in which the limitations in the properties of commercial refractory materials played an important part; in fact, the more immediate concern of steelmakers was bound up with these limitations of effective usage, for it had been abundantly proved that the reactions resulting in the elimination of metalloids from the bath of metal, *i.e.*, interactions between the slag and the metal, were dependent on temperature to a marked degree. The higher the temperature of working, the quicker was the steel production. This was the modern trend, and, consequently, the properties of the available refractories must be reviewed in the light of increasing duties.

Steel Production and Refractory Costs.

Continuing, the speaker said he had been informed that at a very progressive steel plant in the Midlands, with a battery of five basic open-hearth furnaces working for twelve months and making 3,000 tons of steel per week, the cost of refractories per ton of steel averaged about 2s. for the actual open-hearth furnace operation, including carting, and 6s. per ton for operations incidental to the rolling of the metal. This corresponded to a sum of well over £10,000 for a year's working of this plant. In 1920 eight million tons of steel were made by the open-hearth process in this country. This might mean that about £1 million were expended on refractories for this purpose in that year. Such figures indicated the importance of refractory materials to the industry.

Similar conditions entered into the economics of blast-furnace practice. He had been personally acquainted with a number of instances where the lining of a furnace had failed before the production of 100,000 tons of metal. It was very well-known that the relining of a blast furnace was very expensive in time, labour and material. Nevertheless, very little work on the failure of these linings, and the most desirable features of refractories in relation to the design, operation and efficiency of blast furnaces had been completed.

Limitations of Laboratory Tests.

A survey of the principles of iron and steel manufacture (continued the speaker) indicated strongly that a mere laboratory study of refractories normally used in these industries was a very inadequate method of tackling the problems involved in the durability of the linings. A complete study of individual furnace design, operation and efficiency, together with a full knowledge of the properties of the refractories used, was demanded if a proper basis of investigation was to be realised. Such a course of investigation would indicate more precisely the limitations of the refractories, and would show the nature of the compromise, which was so often necessary. It would also make an outlet for the more immediate application of fundamental investigations, which had already been completed by the Association, or which were in the present programme of work. Furthermore, whilst it would stimulate work on fundamentals, it would push the economic aspect of research to the fore.

Refractories and Carbonisation.

Mr. Green went on to remark that an important feature of the trend of modern carbonisation appeared to be the increasing temperature of working, the objects of which were reported as the realisation of larger throughputs and great speeds of working. This feature, together with the necessity for flexibility of working, put a great tax on an installation, and, in fact, necessitated a plant capable of withstanding comparatively drastic conditions. For all carbonising operations, the material of construction must be refractory to heat at the temperatures of working, and the other influences of working. It must maintain itself as a structural entity during working and give a life, long enough to ensure the complete economy of the process. It should possess, as far as possible, thermal properties capable of giving increased efficiency to the process of carbonisation. This definition of the desired attributes was fundamental.

With the increasing duties of modern working, materials which were considered capable of satisfying the demands of the older practice were said to be losing their potency. It was reported that such products could not give a satisfactory compromise of the above requirements when applied to modern conditions. Again, the use of the newer refractories had introduced fresh sources of worry and concern, so that a definition of the limitations of economic refractories under "carbonising" conditions was urgently needed. Again, the question could be asked as to how far the solution of these difficulties could proceed in the haphazard manner

(*Continued on p.* 468.)

Alloys Now Cast in Great Britain.

By Thomas Henry Turner, M.Sc.

(*Continued from page* 428.)

Yellow Metals.

On account of their relative ease of casting and resistance to corrosion, alloys rich in copper, here grouped under the heading of "Yellow Metals," are manufactured in the greatest variety of compositions and mechanical properties. Common brass castings are mostly made from scrap metal, and therefore contain up to 2 per cent. of unintentional foreign elements, as well as the usual 60 per cent. of copper and 40 per cent. of zinc, which most foundrymen profess to aim for in such castings.

A specification for this class of material (B.E.S.A. B14—1918) calls for 55 per cent. of copper as a minimum, and not more than 2 per cent. of total impurities, including lead, the remainder being zinc. These common brass castings must give the following minimum figures from tensile tests:—Ultimate tensile strength, 15 tons per sq. in.; yield point, 6 tons per sq. in.; and elongation, 15 per cent.

The corresponding Admiralty brass specification requires 62 per cent. copper, 1 per cent. tin, the balance being zinc, only 0.75 per cent. of impurities being permitted. The 1 per cent. of tin is deemed beneficial for all brasses in contact with sea water. For much general work, 60 per cent. copper, 39 per cent. zinc and 1 per cent. tin, with varying amounts of lead, is cast, and for railway window frames and similar somewhat superior cast brass, 66.5 per cent. copper and 33.5 per cent. zinc is specified by the users.

Phosphor-Bronze.

For bearings of the copper-rich type, "phosphor-bronze" is usually specified for high-duty purposes, in accordance with B.E.S.A. B8—1917, some details of which are shown in Table VIII.

TABLE VIII.—*Phosphor-Bronze.*

Composition. Per cent.						Properties.		
Cu	Sn	Zn	Pb	P	Mn	U.T.S.	E. Per cent.	——
89	9.5–10	1.5–1.8	—	0.05	0.10	15	10	Admiralty.
88.5	11	—	0.2	0.3	—	—	—	Automobile axle bushes.
85–89	10–13	0.25 max.	0.25 max.	0.5–1.0	—	10 min.	1½–4	Air Board (B. 8).
86.6	11.9	—	—	1.5	—	—	—	Turntable centres.
85.5	10	2	2	—	—	—	—	Gearbox bushes.
85	8	3	3.5	0.5	—	—	—	
84.6	14.6	—	0.8	0.01	—	—	—	
83	10	—	6	1	—	—	—	Locomotive slide valves.
80.2	13.8	2.0	3.5	(remainder phosphor tin)		—	—	Anti-attrition.
80	15	—	5	trace	—	13	5	Locomotive slide valves.
80	14	2	—	(remainder phosphor tin)		—	—	"Bell" for packing rings.
79.7	10	1.0 max.	9.5	0.8	—	—	—	Railway and mill bearings.
90	—	—	20	20 nickel		—	—	Large water-cooled mill bearings.

For bearings subjected to lower loads the use of a plastic bronze is made, in which tin, zinc and lead are found. These are usually made to special specifications, a typical one being:—Copper, 80; zinc, 7; tin, 6; lead, 7 per cent.; ultimate strength, 12 tons per sq. in.; elongation, 10 per cent.; and Brinell hardness, 60.

A.G.M.

Where resistance to corrosion is essential, the so-called *Admiralty Gun-Metal* is extremely popular, and is commonly spoken of as "88/10/2 alloy." The specification which is actually used most at the present time for this type of work appears to be B.E.S.A. B2—1917, but *Admiralty Electrical Bronze*, or "87/7/3/3," is also much used by foundrymen for many castings, owing to its excellent casting properties.

Typical compositions of gun-metals now cast in Great Britain are given in Table IX.

TABLE IX.—*Gun-Metal.*

Composition. Per cent.				Properties.		
Cu	Sn	Zn	Pb	U.T.S.	E. Per cent.	——
88	10	2	0.5 max.	16	8	Admiralty.
88	10	2	1 max.	—	—	General work.
88	8	2	2	—	—	Ditto.
87	9	2	2	14	7.5	Boiler fittings, etc.
87	8	5	1 max.	—	—	Steam valves, etc.
87	7	3	3	—	—	Admiralty electro bronze.
86 min.	10–12	2.5 max.	nil	14	10	Air Board (B. 2).
85.3	14.7	—	—	—	—	Bearing metal.
85	12	1.5	1.5	—	—	Axle-boxes.
85	8	2	5	—	—	"Leaded" for pump liners, where resistance to rubbing is required.
85	5	5	5	—	—	Plumbing fixtures.
84	12	4	—	14	3.5	For white-metalled railway-carriage and wagon-axle "brasses."
83	7	6	4	—	—	
82	5	8	5	—	—	Boiler mountings.
80	17.2	—	2.8	—	—	Gas-meter bearings.
80	3	15	2	—	—	Oil boxes, etc.
77.5	8.5	—	14	—	—	"Plastic bronze" for metallic packing rings.

It is a common practice to add small quantities of nickel to these bronzes to promote soundness.

Bell Metals.

Bell Metals cast in Great Britain are true bronzes, with 17 to 25 per cent. of tin; as a rule, 20 to 24 per cent. of tin is preferred. They are very hard and brittle, with no elongation, and an ultimate tensile strength of 15 tons per sq. in. Silver is not now added, but up to 4 per cent. of lead is often present. They are typically grey-white in colour, and frequently spotted with gold and yellow patches.

Manganese Bronze.

So-called *Manganese Bronze* castings are generally high tensile, complex brasses, and they are often employed as substitutes for steel castings, especially where urgency of delivery is a prime consideration, or when small numbers of the particular castings are required. Its use in this respect, although often resorted to, is not general, on the score of expense. The specification given for its physical and mechanical properties is similar to that quoted for steel castings, and a typical one, used in the foundry of an engineering firm visited, is:—Ultimate tensile strength, 28 tons per sq. in.; yield point, 14 tons per sq. in.; elongation on 2 in., 20 per cent. min.; Izod strength, 15 ft.-lbs. Its typical chemical analysis is:—Cu, 59; Zn, 37.5; Fe, 2.0; Mn, 1.0; tin, 0.5 per cent.; and Ph. Al. Mo, nil.

Observation in service has shown that failures of castings in "manganese bronze" used as substitutes for steel castings have been remarkably few, and these have been traceable generally to unsoundness, which, incidentally, is the most severe problem to overcome in the casting of these alloys.

Specifications for some *High Tensile Brasses* now used are shown in Table X.

The use of the name "Manganese Bronze" for many of these alloys, instead of the nomenclature accepted by the Institute of Metals, dates from the invention and patenting in England, in 1876, of an alloy of this type. This is still known as "Parson's Manganese Bronze," and is cast for ships' propellers and for all kinds of steamship work. Its composition and properties are as follow:—Cu, 56 to 58; Zn, 40 to 41; Fe, 1 to 1.5 per cent.; whilst Mn, Al and Sn are present in small quantities. Its properties are: Ultimate tensile strength, 32 to 34 tons per sq. in.; elastic limit, 16 to 17 tons per sq. in.; elongation, 20 per cent.; specific gravity, 8.4; and Brinell hardness, 120.

Many thousands of tons of ships' propeller castings have been made from similar alloys, in which the zinc is slightly higher, and nickel and manganese replace some 4 per cent. of the copper. This second alloy withstands better the erosion and water-hammer action encountered in running large vessels. One British foundry, which has cast propellers for many of the better-known Atlantic liners and for the largest battle cruiser afloat, names the alloy they have used for this purpose "Turbadium," and informs the writer that its typical properties are, approximately:—*Composition*: Cu, 51.0; Zn, 43.0; Mn, 2.2; Ni, 1.75; Fe, 1.4; Sn, 0.5; Pb, 0.3 per cent.; and As, trace. *Mechanical Properties*: Ultimate tensile strength, 40 tons per sq. in.; elastic limit, 19 to 20 tons per sq. in.; elongation, 18 to 20 per cent.; and Brinell hardness, 180.

This foundry also casts a series of special alloys under the proprietary name of "Immadium," in which No. VI has ultimate tensile strength tons per sq. in., 50 to 52; elongation, 15 to 20 per cent.; Brinell hardness, 200 to 210; and sp. gr., 7.8.

A proprietary range of special brasses and bronzes, introduced by the late Walter Rubel, is also now being cast under licence by several firms, and these so-called "*Rubel Bronzes*" are again copper-zinc alloys, to which additions are made in varying proportions. Nickel, manga-

nese, aluminium, and a fraction of 1 per cent. of iron are added, within well-defined limits, in the form of a special temper alloy; the additions varying from 6 to as much as 21 per cent.

Table X.—*High-Tensile Brasses.*

Composition. Per cent.							Properties.		
Cu	Zn	Sn	Pb	Fe	Mn	Al	U.T.S.	E. Per cent.	——
—	—	—	—	1.25 max.	1.5 max.	—	—	—	Admiralty.
59	37	0.5	nil	2.0	1.0 & Mg	nil nil	28	20	" Mn bronze " (Izod 15 ft.-lbs.).
58	37	—	—	Fe + 5	Mn + per cent.	Al = t.	35	15	" Mn brass " for turbine-pump casings, etc.
57	41.25	1.00	—	—	0.75	—	33	15	" H.T. bronze."
57	39	1.25	0.5	1.0	0.25	— Ni	36	20	" Special Mn brass."
51	43	0.5	0.3	1.4	2.2	1.75	40	19	Propellers.

Table XI gives examples of such alloys, and it should be noted that the latter two alloys, which contain 13 and 17 per cent. of nickel respectively, have recently been extensively employed in high-class shipbuilding. They are both silvery white in appearance when polished, but light yellow after long exposure.

Table XI.—*Approximate Properties of some Chill-Cast Alloys* (made by adding a temper alloy of nickel, manganese, aluminium and a little iron to a copper-zinc base).

Proprietary name.	Percentage of copper plus zinc.	Percentage of temper alloy.	U.T.S. Tons per sq. in.	E. per cent.	Brinell hardness.	Sp. gr.	Principal uses.
Rubel W1	91	9	28–35	20–35	80–100	8.3	Constructional. Propellers.
Rubel H1	89	11	35–44	8–18	150–160	8.2	Piston rings. Rotor covers.
Admiro 1	84	16	28–35	20–40	110–130	8.3	Superheated steam up to 400° C.
Admiro 5	79	21	38–50	5–18	150–170	8.3	Superheated steam over 400° C.

A B.E.S.A. specification now exists for such very remarkable, complex alloys (No. 208—1924), brief details of which are shown below.

Table XII.—*B.E.S.A. Special Brass Castings.* (*Spec. No.* 208–1924.)

Class.	1.	2.	3.	4.	5.
Min. Cu, per cent.	54	54	54	50	50
Max. total of metals other than Cu and Zn	5	5	8	10	13
Zinc	Remainder in all cases.				
Min. U.T.S., tons/sq. in. ..	28	32	34	38	45
Min. E., per cent.	25	18	15	15	12
Proof stress, tons/sq. in. ..	12	15	17·5	20	25

Further particulars of the compositions of such alloys are to be found in the companion specification for *Special Brass Ingots for Castings* (No. 207—1924). The maximum lead content permissible in each of the five grades is 0.5 per cent., and no one metal shall exceed 3.0 per cent. in grades 1 and 2, or 5.0 per cent. in grades 3, 4 and 5, with the exception of copper and zinc. The " proof stress " specified above is applied for 15 seconds and removed, and must not produce a permanent elongation of 0.15 per cent. of the gauge length.

Particulars are also given here of some *special nickel-toughened yellow-metal castings*, which were exhibited this year at the International Foundry Exhibition by a well-known British foundry.

The above yellow-metal alloys, with low nickel contents, form an intermediate group of alloys between the normal bronzes and the high-nickel complex bronzes which are generally cast by specialist firms catering for steam users. For high-pressure steam valves a number of alloys are now being cast which may be regarded as copper-nickel or Monel metal, to which tin has been added. In some cases, further small additions of other metals are made, such as chromium, iron and manganese, but the alloys appear to be, in the main, tin-hardened copper-nickels. In one foundry visited, valve parts for medium high-temperature steam are cast from copper 75 per cent., nickel 15 per cent., tin 8 per cent., and manganese 2 per cent.; but a works metallurgist with exceptional experience of these special castings informs the writer that the best properties (40 tons per sq. in. U.T.S. at ordinary temperatures; 20 tons per sq. in. at 600 deg. C.) are obtained from those alloys which contain 40 to 50 per cent. nickel and 10 to 12 per cent. tin. These valve-seating alloys have a Brinell hardness of about 285 at ordinary temperatures.

Table XIII.—*Typical Nickel-Toughened Yellow Metals.* (*Exhibited at the London Foundry Exhibition*, 1929.)

Ni. Per cent.	U.T.S. Tons/sq. in.	E. Per cent. on 2 in.	—
1-1.5	16-18	15-25	Nickel toughened gun-metal for dynamo end bearing frame and retaining ring.
5	14-18	10-15	Superheat steam bronze for large slide valve and small turbo-generator bucket wheel blank.
2-3	16	4-6	Nickel toughened bronze for small slide valve.
1-2	12-16	5-10	Nickel toughened bearing bronze for dynamo slip ring.
0.5-1	15	4-6	Nickel toughened pump bronze for impeller guide ring.
1	35	25	Nickel toughened manganese bronze for launch propeller.
1-2	17-20	4-8	Nickel toughened gear-wheel bronze for automobile worm wheel.

Aluminium Bronzes.

The specific gravities of many proprietary bronzes betray the fact that they are complex aluminium bronzes, but under its own name *aluminium bronzes*, as such, does not appear to have been adopted in Great Britain as a foundry alloy, to the same extent as it has been in some other countries. During the last few years it has attracted greater notice, and is now being chill- and sand-cast for use in many industries. As the fatigue strengths of these alloys are superior to those of brass, bronze and phosphor-bronze, and the specific gravity slightly lower, they merit more attention.

In Table XIV particulars are given of aluminium bronze as cast at a works visited by the author. No. 1 is said to be the easiest to cast, and is used almost solely on account of its excellent resistance to corrosion. It withstands cold weak sulphuric acid, and also weak hydrochloric acid, but cannot resist nitric acid. No. 2 is used for gears and other parts requiring strength, and No. 3 is used where the highest strength is required. These alloys have not been standardised, and the writer is indebted to a foundry owner for these figures of alloys cast in his own works.

Table XIV.—*Cast Aluminium Bronze* (*casting temperatures* 1,150 to 1,300 *deg. C.*).

—	Composition.	Y.P.	U.T.S.	E. Per cent. on 2 in.	Brinell hardness.	Sp. gr.
No. 1—	Cu 90 Al 7 Fe 3	15	34·5	21	104	7.8
No. 2—	Cu 87 Al 10 Fe 3	13	35	15	130	7.6
No. 3—	Cu 84 Al 10 Ni 3.5 Fe 1.5 Mn 1 Si —	23.5	42	10	160	7.5

The works manager of another firm, which foresees, and has planned for, a big development for aluminium-bronze die castings, sent the author the following data (Table XV) regarding some of the more generally used alloys.

Table XV.—*Die-Cast Aluminium Bronzes.*

Cu. Per cent.	Al. Per cent.	Fe. Per cent.	U.T.S. Tons/sq. in.	E. Per cent. on 2 in.
90.3	9.7	—	29.9	14
89.6	10.4	—	33.6	23
90.0	8.6	1.4	31.7	42
88.8	9.5	1.6	32.5	23
87.3	10.5	2.2	35.6	13
87.0	10.2	2.8	39.4	12

Aluminium bronzes are also cast by adding proprietary temper alloys to copper, with the results shown in Table XVI.

Table XVI.—*Proprietary Aluminium Bronzes.*

Cu. Per cent.	Temper alloy. Per cent.	U.T.S. Tons/sq. in.	E. Per cent.	Brinell hardness.	Sp. gr.
77—	Al, Ni, Fe, Mn } 23	35-44	8-15	140-170	7.54
88—	Al, Ni, Fe, Mn } 20	31-38	8-15	130-150	7.54
80—	Al, Fe, Mn } 20	38-44	5-15	140-170	7.4
80—	Al, Fe, Mn } 20	31-38	15-30	130-150	7.4

P.M.G. Alloy.

A new alloy has recently been introduced in Great Britain, showing exceptional promise in its application to engineering; certain high-duty castings having already been made and approved for British and Foreign Admiralty work. This alloy, known as " *P.M.G.*," replaces gun-metal, to which it has proved to be considerably superior in mechanical properties, ease of pouring, and mechanical stability at elevated temperatures. It is essentially a complex silicon-manganese-copper alloy, containing more than 90 per cent. of copper, and is thus somewhat lighter, and appreciably cheaper, than ordinary bronze.

The properties of " P.M.G. metal " in the form of castings are: Sp. gr., 8.44; Izod,

(*Continued on page* 462.)

Hidden Facts in Oil-Sand Practice.

By F. Hudson.

(*Continued from page* 446.)

Effect of Binders Relative to Core Strength Permeability and Finish.

Every user of oil sand desires that his cores should possess ample strength, be highly permeable and give a good finish. At the present time, the strength of cores used in foundries varies from 3 to over 400 lbs. per sq. in. tensile, according to the type of castings being made. For example, in certain types of engine or pump assemblies a finished core may be easily composed of 10 core pieces requiring fitting and jointing together on jigs. This entails possibly a large amount of handling and considerable rubbing down. For this class of work, a very strong core is essential with sharp edges. On the other hand, for aluminium work a rather weak core is most suitable, which will readily break down and allow contraction to take place. In conjunction with the degree of strength, permeability is an important factor, and this, again, must depend on such points as whether the core is to be used for jacketed or port core work, etc., together with the volume of gas it must vent.

Strength, permeability and finish are determined to a large extent by the binder used. For example, practically every Paper so far published has suggested that linseed oil is the best and most economical binder to use. It undoubtedly gives strong and open cores, but, on the other hand, the finish nine times out of ten leaves much to be desired. In fact, with straight linseed core mixtures the only good finished cores obtainable are in those cases of large cores which are sleeked by hand before drying.

Many small cores cannot possibly be finished off in such a manner, and, due to the tendency of linseed-oil mixtures to stick to the core boxes, lack good finish. Furthermore, linseed bonded cores give off quite a large amount of gas on casting. Molasses, on the other hand, gives off very little gas on casting, but the cores are weak, although they leave the boxes well if used in the correct proportions. Molasses also suffers from fermentation, which gives variable strengthed cores. Wood extract behaves similarly to molasses without the presence of fermentation, although this latter material dries out very rapidly on the bench.

The binding mediums employed by founders are numerous, and invariably the single simple binders, such as, say, linseed oil, molasses, core gum, wood extract, etc., suffer from some defect or other when used alone. For example, linseed oil invariably produces rough cores through the sand sticking to core boxes, and is very variable in price. Molasses is subject to fermentation, and consequently variable strengthed cores are obtained; cores bonded with wood extract are too easily burnt in drying, etc. This is well brought out in American practice, as, even when using linseed oil the custom to-day is to use compounded oils containing some ingredient to minimise the sticking tendency of straight linseed. Modern practice necessitates the use of compounded mixtures to obtain the most satisfactory results.

In THE FOUNDRY TRADE JOURNAL for April 26, 1928, appeared an article by "Mancunian" on the "Mechanical Aspect of Oil-Sand Cores." This writer suggested that certain facts should be made clear to the foundryman in order to enable him to obtain and use the most satisfactory binding medium for his purpose. The facts outlined in brief are as follow:—(1) The relative proportions of the mixture required to give a certain definite strength against ordinary commercial linseed oil; (2) particulars of the times and temperatures of drying necessary to give those cores a maximum strength; (3) tests of the strengths of such standard cores after being in contact with damp sand for different periods; (4) the volume of gas evolved from these cores and the rapidity with which it is evolved at some definite fairly high temperature; and (5) the bond strength in the green core.

Effect of Binders Relative to Core Strength, Permeability and Gas Solution on Casting.

The strength of the finished baked core depends, firstly, upon the degree of green bond required in the core mixture to make the core. The stronger the green bond obtained, then the lower the strength after baking. This is conclusive on all mixtures which do *not* go through a softening period when first placed in the drying stove, and it is matterless whether the green bond is imparted by the binding compound used or by the addition of blended sands. This statement must be remembered when comparison is made upon the core strength imparted by various binding media. A green-bond strength figure of 2.0 in. is amply sufficient to cover general core-room practice. Table VI illustrates quite clearly and definitely the effect of too high a green-bond strength on cores made from "Glyso" semi-solid and linseed oil. In the first case the green-bond strength is imparted by the compound alone, whilst in the other case the green bond is obtained by the addition of a bonded sand. It is very important to use this class of core mixture with the lowest possible green-bond strength if strong cores are required with sharp edges; the addition of suitable water percentages being the best way to control this factor, together with use of semi-solid binder. Table VII illustrates some physical test results obtained by the use of various binders, and no remarks need be passed, as a study of the results obtained is evident. In regard to binder effect on permeability, this is so slight that no mention is necessary, except to state that core permeability is determined primarily by the sand used, and, secondly, by the amount of gas generated from the binder and sand on casting.

Effect of Binder on Core Finish.

The binder plays quite an important part in giving a good finish to cores, and in this respect the creams and semi-solid compounds are infinitely superior to the thin oils. Sand possessing a fair green-bond strength is essential for the production of smooth-surfaced cores.

TABLE VI.—*Effect of Green Bond Strength on Core Strength after Baking.*
(All Cores baked at 400 deg. F. for One hour.)
Green Bond Strength imparted by Binder.

Mixture.	Tensile. (Lbs. per sq. in.)	Transverse. (Lbs. per sq. in.)	Gas content. (C.c. per grm.)	Perm. (Secs.)	Green dropping test. (Inches.)
100 parts Southport sea sand, 4 parts Glyso S.S., ¼ part water	448.0	80.125	21.34	50.0	2.18
As above, but without water	308.0	55.125	25.40	56.0	2.75
	Green Bond Strength imparted by Bonded Sand.				
100 parts Southport sea sand, 3 parts raw linseed oil, 1 per cent. water	336.5	73.69	22.8	53.5	0.9
76 parts Southport sea sand, 24 parts Mansfield red sand, 3 parts raw linseed oil, 1 per cent. water	185.0	29.25	17.85	78.0	1.23

Use lowest green bond strength practical for core production with semi-solid binder, plus water percentage. The use of linseed oil and bonded sands is productive of weak cores.

The last point is a consideration of the degree of moisture absorption that takes place in baked cores made from certain classes of core compounds. The defect, is such it can be called, is apparent by a softening of the core. Water absorption is accentuated very considerably by incorrect baking, and to obtain the best results from binders susceptible to this trouble it is necessary to slightly overbake the cores to ensure complete carbonisation of the binder. However, it must be clearly understood that this is only of consequence when cores must be left standing in green-sand moulds overnight. Table VIII shows the results of a carefully conducted test under practical conditions giving the effect of moisture absorption on various binders. The test cores were allowed to stand in a green-sand mould containing 7 per cent. moisture for

TABLE VII.—*Physical Data from Various Binders using Southport Sea Sand.*
(Baked 400 deg. F. for One Hour.)

Mixture.	Tensile. (Lbs. per sq. in.)	Transverse. (Lbs. per sq. in.)	Gas evolved. (C.c. per grm.)	Perm. (Secs.)	Green dropping test. (Inches.)
3 per cent. raw linseed, 1 per cent. water	336.5	73.69	22.8	53.5	0.9
4 per cent. (dextrine 1 part, water 1 part)	204.0	31.87	19.1	53.0	1.1
4 per cent. molasses	191.5	27.0	16.15	51.0	1.3
4 per cent. wood extract	130.0	12.38	14.6	43.0	1.1 (These test cores baked at 360 deg. F.)
4 per cent. Glyso S.S. plus water to give correct green bond	448.0 (Dried strength varies according to green bond.)	80.125	21.34	50.0	2.18
3 per cent. Glyso 444, 1 per cent. water	359.0	97.03	22.05	48.0	1.1
3 per cent. Glyso N.R., 1 per cent. water	322.0	66.5 (Linseed oil substitute.)	20.6	58.0	0.9
3 per cent. Glyso-Brunol	349.0	66.94	22.41	51.0	0.9
1 per cent. water	*241.0	46.68	17.67	48.0	0.9

* Low gas grade.

24 hours and show the reduction in strength before and after standing. All the cores were slightly overbaked, and it is apparent that, although a reduction in strength does take place in certain binders, the reduction is insufficient

Table VIII.—*Effect of Moisture Absorption on Baked Cores.* (*Transverse Test only.*)

Mixture (with Southport sea sand).	Transverse strength. (Lbs. per sq. in.)	
	After baking.	After lying in green sand mould for 24 hours.
4 per cent. Glyso, S.S.	44.73	29.4
3 per cent. Glyso, 444	68.97	49.23
3 per cent. raw linseed	74.25	41.1
3 per cent. Glyso-Brunol	50.20	41.9

Note.—Moisture is not actually absorbed and the gas content remains unaltered. The damp air only lowers the strength of the binder film.

to weaken the core so far as casting stresses are concerned, although the author would certainly remove the cores from any moulds not cast that day.

The value of these binders will be increased enormously in the near future, as they lend themselves most readily to reclamation of not only the core sand but of the binder itself, and before long the author confidently predicts that used core sands, say, containing 4 per cent. of binder originally, will be used over again, with the addition of only 1 to 2 per cent. new binder, and produce better results than the original mixture. Before closing, the author would like to draw attention to a new binder discovered which is likely to supersede linseed oil. The binder is an oil, which at present does not give green-bond strength and is only slightly weaker than linseed-bonded cores when freshly baked, although it gives improved strength for general practice. This may seem rather a contradiction, but the meaning is obvious when one appreciates that laboratory results are always better and more consistent than works practice, and most foundries cannot guarantee perfectly uniform stove temperature nor standard core sections, and accordingly out of a batch of dried cores some are of correct strength, whilst others may be slightly under or over baked, and not so strong.

This new oil, whilst it dries rapidly, is not nearly so susceptible to overheating as linseed oil, and accordingly produces more uniform practical results. It can be used at 2½ per cent. with sand, and the mixture leaves the core boxes in many cases without rapping and producing a very much superior skin on the core. It evolves less gas on casting and is impermeable to moisture. In fact, the strength of the core is unimpaired by one hour's immersion in water. Finally, the cost is very much cheaper than linseed and not subject to market fluctuations. It should be clearly understood that this product contains no linseed oil and is not a so-called substitute, and has been registered under the name of "Brunol."

Discussion.

Gas Percentage.

The discussion was opened by Mr. C. Gresty, Branch-Past-President, who said that a point which he would like explained was the gas content of sands tested without a binder at all. Mr. Hudson had said that these sands had been baked first. In that case, must one understand that during baking gas was actually absorbed and then liberated? If that was so, if the sand was not baked first other than plain drying at 100 deg. C., what would the result be then? He thought Mr. Hudson's point on relative values of grain bond strength and baked strength ought to be rather interesting. A point not appreciated was that high grain bond meant low baked strength. Frequently great stress was laid on having high grain bond, possibly because it meant having high baked strength as well.

Mr. Hudson stated with regard to his (Mr. Gresty's) statement about the gas evolved, the sand was baked so as to obtain a comparable result. After the sand came out of the oven it would resemble that which came out of the foundry. The gas was evolved purely out of the sand. It might be due to sea coal, *i.e.*, carbon, or other material in the sand, which evolved gas. If they had just dried the sand at 100 deg. C. they would have obtained a still higher gas percentage.

Standardised Sieving Tests.

Mr. Logan, referring to Mr. Hudson's remark as to the scarcity of research work which had been done on oil sands generally, said that, although he agreed that this was quite true, he thought mention should certainly be made of the good pioneer work which had been done by Mr. W. West, of Leyland. With regard to sieving sands, Mr. Logan said that this was a very vexed point, and, in his opinion, it was necessary to adopt a standardised method. The author had stipulated 15 minutes, but he thought it was rather long, as a fictitious result might be obtained, caused by the sand grains breaking up. The question of gas evolution Mr. Gresty had already raised. He would like to further ask whether a standard amount of oil had been added in each test-piece, otherwise the gas evolved would be quite misleading. He would also like to know why water increased the strength on baking, and why green strength gave a lower tensile. He wondered whether the lecturer had any theories on that point. The gas evolved from sea sand might be caused by the reason that Mr. Hudson had given. It might also be due to sea shell. If sea sand was examined under the microscope very small portions of sea shell were visible. Quite possibly it was due to the breaking down of that sea shell and the evolution of CO_2 from it. The figure was certainly quite amazing to him. He never would have expected untreated sea sand to give off so much gas.

Mr. Hudson replied that he was in agreement with Mr. Logan's views as to the need of standardisation of sieving. He followed standards already existing, those used by the American Foundrymen's Association. Fully 90 per cent. of the sands used were clean clay-free sands. When doing sieve tests on any sands which had clay, he always washed the clay from the sand first. With regard to the gas evolved on casting, those were very carefully measured out with regard to the binder added. If the amount of binder were varied, the mixture was indicated at the same time. With regard to the effect of water on sands, there was the type of binder which would thin down and mix with water readily. In the case of linseed oil, he was not in favour of emulsified oil; if a small amount of water were added to the sand, the oil spreads more easily. Oil would spread more easily over water than over sand. Better and more uniform mixing was obtained. In the water-soluble type of binder a more effective film was obtained over the sand grains. The result was that they obtained stronger cores. It all amounted to an effective distribution of oil over the sand grains. The temperature at which the gas was generated was mentioned in the Paper, about 850 deg. C. They had found that on a small gas-fired furnace, running for about half an hour before they did the tests, the maximum temperature was obtained and only varied about 8 deg. The apparatus showed such startling results that they had modified it. The gas from any baked core was increased by high temperature, but by how much he did not know, although before long he would be able to give them the actual amount of gas generated and the temperature. He intended to do tests at the actual casting temperature of different metals.

Oil Sand for Large Castings.

Mr. J. M. Weir recalled that in that hall in 1917 a lecturer had advocated oil-sand cores. As some of the members might remember, at that time he was making some very large castings. He had asked the lecturer whether he advised him to make the cores for such castings with oil sand. He had made the cores according to instructions out of oil sand, and the unfortunate part was that it had cost £365 to take the cores out of the castings. Mr. Hudson had made no mention of the thickness of the metal into which he proposed to put the cores. He thought that oil-sand cores were satisfactory for small castings, but would they meet the requirements of the North-East Coast in Diesel castings?

Mr. Hudson replied that he thought that the cores they had seen that afternoon, at the Close Works of Messrs. Sir W. G. Armstrong Whitworth & Company (Engineers), Limited, made in oil sand in heavy castings, and the results obtained were a complete answer to Mr. Weir.

Boiled Linseed Oil Unnecessary.

Mr. Scott observed that Mr. Hudson had mentioned raw linseed oil as being used in oil-sand cores. He took it that he had meant boiled oil, as in his experience it was impossible to use raw linseed oil.

In reply, Mr. Hudson said that he had made experiments with boiled oil and had come to the conclusion that it was a waste of money. It had practically no bond strength. With boiled oil one obtained slightly stronger cores, but the difference in strength was not sufficient to warrant the increase in price. Linseed oil was about 1s. 6d. per cwt. cheaper when bought raw, and excellent results were obtained with it in the foundry as far as strength was concerned. Differences in strength between boiled and raw linseed oil were practically negligible. In his opinion the only value of boiled oil was to the painting trade. There was no need to boil it before using, as when the cores were baked the oil went through the process of boiling.

Proper Mixing Essential.

Mr. W. J. Paulin said, in reference to the gas evolved from the core, that it appeared that the increase in the amount of gas evolved when there was a greater amount of metal around the core and at a greater temperature was out of all proportion to the increase in the temperature. Apparently, if the gas did not come from the binder, it must come from the sand. In many works there was not a proper method of mixing oil and sand for cores. When it was properly mixed by a mechanical mixer, about half the binder could be eliminated. He had been interested in Mr. Hudson's mention of the fact that water assisted the union of oil and sand grains. Actually they themselves deliberately mixed water with sea sand before mixing oil with it and got a stronger core. However, he did not think this was necessary if a mechanical mixer were used. He had often heard it stated that it was better to obtain sea sand as far as possible from the sea. The idea was that the condition of the sand became rather different as the rain and wind acted upon it, the rain having the effect, he supposed, of washing some of the salt out of it. Would there be any virtue in that? Mr. Hudson had referred to the fact that oil-sand cores which had already been used were actually better if they were used over again. Had they to understand that less gas was evolved or that less oil was needed, or did one follow the other?

Mr. Hudson, speaking with reference to Mr. Paulin's remarks about the high proportion of gas evolved, said there were about 24 c.cs. of gas generated from 3 per cent. of linseed oil mixed with Southport sea sand at 800 deg. C. With

(*Continued on page* 464.)

Payment by Results.

By "Ecossais."

Any system of payment by results should before adoption be carefully considered, not merely for its immediate effects, but for its general effects on future cost of production and the ultimate volume of output.

In order to get the best results it is necessary that the confidence of the employees should be obtained, and also that unscrupulous methods, tending to weaken such confidence should be firmly suppressed. At the same time, methods which enable employees to earn abnormal bonus for work only deserving the normal bonus cannot be too strongly criticised. The effect of such methods is sure to rebound eventually to the disadvantage of both employer and employee, and to the benefit of some competitor, for the reasons given below. In order to retain the confidence of employees, times allowed or piecework prices when once fixed should on no account be reduced, except in cases of error or by a free and mutual non-coercive arrangement with the employees. It should be unnecessary to add, also, that such adjustments should be as few as possible for the same reason.

As an example, we may now assume that on a certain type of non-proprietary work a firm pays bonus amounting to an average of, say, 70 per cent. This information will eventually get to the ears of enterprising salesmen in the same line of business but representing firms whose employees receive the recognised average for bonus, namely, 33⅓ per cent. The difference is sufficient to enable the latter firms to quote considerably lower, and other conditions as plant, equipment, etc., being equal, they will secure future orders without cutting. The original supplier cannot hope to compete, except by reducing bonus times or piecework prices. The question of labour is quickly solved if it should arise, as the employees of the original supplier are, owing to the loss of orders, available for the new supplier. These employees will then work more contentedly for the lower bonus than if they had stayed on at their original firm with bonus cut down.

Rate-Fixing and Review of Bonus Schemes.

From consideration of the above it will be seen that an important consideration is the appointment of an efficient rate-fixer. A rate-fixer, to be successful, must be a keen observer and have had a varied practical experience, so as to enable him to analyse different processes into the different operations, his experience then enabling him to build up a suitable rate or price for the job. He will make frequent time and motion studies with the object of ascertaining how and where time is lost.

Under the Rowan system, the firm is protected somewhat against faulty estimates, as shown below. To take an extreme and hypothetical case, let us assume that a job comes along and the fact that special tackle exists has not been noted. Also faulty estimates are made and a bonus time of 100 hours has been fixed. When the job comes to be made, a conscientious employee works away at it and completes in 40 hours.

The method of calculation of bonus earned under the Rowan system is as follows:—

$$\frac{\text{Actual Time} \times \text{Time Saved}}{\text{Time Allowed}} = \text{Bonus hours payable;}$$

$$\text{thus } \frac{40 \times 60}{100} = 24 \text{ hours.}$$

Total hours payable on the job = 40 + 24 = 64 hours, the idea being that the employee gets a percentage on his actual hours equal to the percentage of the allowed time saved, in this case 60 per cent.

Under the Halsey system the employee would get 50 per cent. of the hours saved on the job, thus,

Time Allowed — Actual Time = Time Saved;

$$\text{thus } \frac{\text{Time Saved}}{2} = \text{Bonus hours payable.}$$

Again, 100 hours − 40 hours = 60 hours

$$\text{and } \frac{60 \text{ hours}}{2} = 30 \text{ hours payable.}$$

Total hours payable on the job = 40 + 30 = 70 hours.

In this case the employee gets equal to 75 per cent. added to his actual time.

If we can imagine an extreme case of a man making a 100-hour job in 1 hour, we shall see how, in the case of such an obvious error, the employer is protected by the Rowan system.

$$\frac{\text{Actual Time} \times \text{Time Saved}}{\text{Time Allowed}} = \text{Bonus hours payable;}$$

$$\text{thus } \frac{1 \times 99}{100} = \frac{99}{100} \text{ hour.}$$

$$\text{Total time payable on the job} = 1 + \frac{99}{100} = 1\frac{99}{100} \text{ hours.}$$

Under the Halsey system,

Time Allowed — Actual Time = Time Saved.

$$\frac{\text{Time Saved}}{2} = \text{Bonus hours payable}$$

$$= 100 - 1 = 99,$$

$$\frac{99}{2} = 49\frac{1}{2} \text{ hours.}$$

Total time payable on the job = 1 + 49½ = 50½ hours.

Thus under the Rowan system the man would get 99 per cent. bonus, while under the Halsey system he would get 100 × 49.5 = 4,950 per cent. bonus.

Necessity for Mutual Goodwill.

It may be argued that from the employees' point of view the Halsey is the better system, but it is obvious that employers paying bonus regularly at the above rate could not hope to get any business in an open market, and the employee would eventually have to seek fresh employment. The writer, however, does not imagine that any employee or group of employees would consistently demand under the Halsey system that such a time should be kept unaltered. On the other hand, it must not be assumed that under the Rowan system care must not be taken in assessing the time, as much depends on the type of employee who gets such an over-assessed job, as in every works employees will be found who use the time allowed to form an idea of how much time to spend on the job, and many instances could be quoted of employees repeatedly working to the time allowed, although the jobs in question have proved good bonus jobs, giving from 30 to 50 per cent. when worked by a man who is out to earn bonus.

With such employees, any system would, of course, fail to give good results, and the above example also gives a good reason for individual bonus as against collective bonus. Maybe, in the past, such individuals as quoted above have been unfairly treated by previous employers, and even at the expense of losing bonus become apathetic, deciding that all such schemes are for employers' benefit only. One way is to dispense with the services of such individuals, but the better way is to expend a little patience, and, by showing them that it is the employer's intention that they benefit financially, regain their goodwill.

An example of this type occurred within the writer's experience a few years ago. The job was given a bonus time of 3¾ hours, and three employees had the job in their turns, all taking exactly 3¾ hours. As the firm were confident that the time was sufficient, a fourth employee was put on, and without any apparent exertion used up the three sets of tackle available for the job, asking for a fourth set which was supplied. After a few days this employee was producing four off the job daily, in 8 hours, thus earning under the Rowan system approximately 3¾ hours' bonus daily, as shown below,

4 at 3¾ = 15 hours.

$$\text{Thus } \frac{\text{Actual} \times \text{Time Saved}}{15} = \frac{8 \times 7}{15} = 3\frac{3}{4} \text{ hours approx.}$$

Many times the inability to earn bonus is due to the unsuitability of an employee for the work on which engaged, a case of round peg and square hole. To illustrate, a recent case may be cited. A piecework job was given a price of 2s. 4d. each. The first employee made three first day and never exceeded five, but according to the pricing of the job should have made six to earn approximately 33⅓ per cent. As the job was urgent another employee was tried, and almost immediately made ten per day with a much better finish.

From the first employee's trial it would appear that the price was too low, while from the second employee's trial the price appeared too high. Actually the price was correct, but one employee was unfitted and the other was specially fitted for the task, and the employer was able to please the customer by delivery to time.

There are several other bonus schemes instituted by different firms, all having the object of increasing the output. Any scheme which effectively increases the output along with the amount of bonus paid to employees in proportion may be considered satisfactory and need not carry any label.

Several schemes have, however, been put into operation by simply putting in a rate-fixer who frames his own rules. If he keeps the two objects of bonus schemes in front, namely, that for an increase in output, an increase in the amount of bonus must be given, then both parties will benefit.

If his methods are just to tack on 33⅓ per cent. as bonus, or vary this from, say, 25 to 40 per cent., and the employees are still working at the day or timework speed, then the most important object, increase of output, will be lost, and such output as given will cost more. It is well known that in the early stages of manufacture of most new articles the production times may be much longer than when the jobs have got running smoothly. A rate-fixer's duties are not to judge a job from the first few articles, but to determine by frequent time studies, if necessary, the estimated possible output from the machine, equipment, or space occupied. From this output he must be prepared to give good bonus, and if this output, as often happens, is exceeded, he should pay more.

It is definitely wrong to fix times on the basis of the early stages, as this becomes equivalent to paying bonus on ordinary output. If the jobs are such as cannot be estimated with a reasonable degree of accuracy, some such system as the Rowan should be adopted.

There are few jobs, and more especially those depending on manual operations, on which the production cannot be increased without necessarily distressing conditions and actually in many cases with less fatigue due to wasted energy.

Fixing Piecework Prices.

The fixing of piecework prices is often complicated by the existence of long-standing prices, and since the fixing of which advances or reductions on wages have been made. Assuming a firm just commencing, it is, of course, a clean start, and the task is much simpler. In order that a price shall be satisfactory it is generally considered that the price must be such as will give the average employee the opportunity to

earn 33⅓ per cent. over the basic rate excluding war bonuses (added during the Great War to compensate for increased cost of living).

A typical case may be taken as follows: The standard rate for a certain type of employee is 65s. per week, made up of 55s. basic rate and 10s. war bonus. So that a pieceworker of average ability must be able to earn at least 55s. plus 33⅓ per cent. plus 10s. = 83s. 4d.

Assuming again that all piece prices are plus 10 per cent. owing to fluctuation in wage rates and that the week consists of 47 hours. The prices of jobs must then be such that when 10 per cent. has been added to piecework earnings the wage, less war bonus, equals 55s. plus 33⅓ per cent. = 73s. 4d. This amount then equals 110 per cent. of the piecework earnings, and the actual basic earnings, subject to 10 per cent. addition, will be approximately 66s. 8d. Proof: 66s. 8d. plus 10 per cent. = 73s. 4d.

Hence for 47 hours the average man must earn 66s. 8d. basic, equal to approximately 1s. 5d. per hour for 47 hours. This rate per hour must now be used in estimating piecework prices, so that the rate-fixer says in effect: "This is a 2-hour job, the piecework rate must be 2s. 10d."

On the same basis an estimated 2½-hour job = 1s. 5d. × 2½ = 3s. 5½d. A collection of jobs taking 47 hours would give 1s. 5d. × 47 = 66s. 7d. The employee with such a collection would receive the following: Basic earnings, 66s. 7d.; 10 per cent. addition, 6s. 8d.; war bonuses, 10s.; total wage, 83s. 3d.

This figure is approximately equal to the desired figure of 83s. 4d., although to be strictly accurate the figure of 1s. 5d. is slightly low by a very small fraction of a penny, and granted that the time assessments of 2 hours on the 2s. 10d. job and 2½ hours on the 3s. 5½d. job are only approximate, the earnings shown could be considered as a fair piecework wage for a man of average ability. The rate-fixer may think that the 2-hour job would be better described as 1 hr. 55 min., and such a case would balance the slight deficiency.

In the event of a dispute and it being established that a price is low, such a price can be lifted, and in order that no ill-feeling might be created, this should be done quite conscientiously. On the other hand, reductions should be extremely rare and then only, as previously stated, in case of error or obvious mistake and by free agreement with the employees. It is on this account that the fixing of prices too high at the commencement should be avoided and, with good intentions existing on the side of employer and employed, real grievances should be brought down to a minimum. It should be added that when such grievances, if any, do arise it is always advisable to discuss them openly with the employees concerned, as in all cases the introduction of outside opinions only serves to widen the grievance often due to a lack of knowledge on the part of the outside parties as to the real state of affairs and special conditions prevailing in the works concerned.

Iron and Steel Output in November.

The National Federation of Iron and Steel Manufacturers report that the number of furnaces in blast at the end of November was 163, a decrease of three since the beginning of the month. The production of pig-iron in November amounted to 631,400 tons (compared with 688,700 in October and 544,400 tons in November, 1928); the production included 179,100 tons of hematite, 279,900 tons of basic, 126,100 tons of foundry, and 23,800 tons of forge iron. The November output of steel ingots and castings amounted to 815,000 tons, compared with 889,800 in October and 762,500 tons in November, 1928.

The Société des Fonderies de Pont-à-Mousson, of France, has obtained an order for 5,000 tons of cast-iron pipes for the Athens waterworks. The price is reported to be £8 15s. per ton.

Annealing Malleable Iron.

SHORT-CYCLE METHOD.

For a number of years, says the "Iron Trade Review," considerable effort has been devoted by many producers of malleable cast iron and other investigators to develop a method which would decrease, to a large extent, the time necessary to anneal or heat treat white cast iron of the proper composition and convert it into the commercial product known as malleable cast iron. The mechanism involved in converting the white or hard iron into the blackheart or malleable cast iron includes the absorption of free cementite into the solid solution of iron and carbon, and the precipitation of the absorbed carbon from the solid solution as a form of graphite called temper carbon.

Time-Temperature Functions.

Some time ago the General Electric Company, Schenectady, N.Y., began an investigation to determine the mechanism of carbon precipitation with a view to a possible shortening of the process. Their efforts were successful and resulted in the development of a short-cycle annealing process whereby the time required is between 28 and 30 hrs. Investigation showed that the absorption of free cementite into solid solution was a question of temperature and time. At 1,100 deg. C. (2,012 deg. Fah.) it was found that, solution was effected in approximately 15 min., while at 900 deg. C. (1,652 deg. Fah.) it took about 30 hrs. With only a drop of 50 deg. from the highest temperature or at 1,050 deg. C. (1,922 deg. Fah.) it took 8 times as long to effect solution, or 2 hrs. At 1,000 deg. C. (1,832 deg. Fah.) the time required was 12 times that at 1,000 deg. or 3 hrs. However, the higher temperatures are too close to the softening point of the iron to result in much commercial value, while temperatures below 900 deg. C. (1,652 deg. Fah.) are too low for rapid absorption of cementite.

After data were obtained on the absorption phenomena, it was necessary to study precipitation of the carbon. As in the case of absorption, precipitation also is related to time and temperature, and it was found that at 900 deg. C. (1,652 deg. Fah.) practically no precipitation had occurred at the end of 100 hrs. Lowering the temperature increased the precipitation rate, which reached a maximum between 750 and 700 deg. C. (1,382 and 1,292 deg. Fah.). Below 700 deg. precipitation of carbon is retarded, and at 650 deg. C. (1,202 deg. Fah.) no precipitation is evident.

Electric Furnaces Used.

With data at hand on the minimum time required for solid solution and the maximum rate of carbon precipitation, experimental 130-kw. electric annealing furnaces with a capacity of 2,000 lbs. of castings were built by the General Electric Company to try out the method on a commercial scale. These furnaces were operated until recently, when a new installation of three 325-kw. electric furnaces with a capacity of 6 tons was put into operation. The heating elements of the furnaces are nickel-chromium, and are arranged to be connected in 3-phase or single phase to give a power range of 52,170 or 325 kw. The weekly capacity of the furnaces is 100 tons, and the average annealing cycle is 28 hrs.

Essentially, the process consists in rapidly heating the castings to the maximum temperature, which is 1,000 deg. C. (1,832 deg. Fah.), and holding at this temperature for 4 hrs. The temperature of the castings then is reduced to 740 deg. C. (1,364 deg. Fah.) in 4 hrs. The castings are held at 740 deg. in another furnace for 4 hrs. and then the temperature is dropped to 730 deg. C. (1,346 deg. Fah.) and held at this temperature for 4 hrs. At the end of this period the temperature is lowered to 720 deg. C. (1,318 deg. Fah.), and the castings held at this temperature for another 4 hrs. The castings then are removed and allowed to cool in the air or in a cooling furnace.

Use of Standard Test Bars.

Test bars are included with each heat, and these are removed at various times and examined to check the heat treatment. These bars are arranged in step form with the largest section 2 in. sq. and decreasing in three steps to 1½, 1 and ½ in. sq. On completion of the annealing cycle at the 730 deg. C. stage some of the castings are fractured and examined. If the examination shows that the annealing is not satisfactory, due to faulty composition of metal or other reasons, the temperature is raised to about 800 deg. C.; the castings allowed to soak for a short period, and then the temperature is dropped to 740 deg., etc. This secondary treatment will require about 15 hrs. more, making the complete cycle 43 hrs.

Previously it was stated that the castings were held at the high temperature (1,100 deg. C.) for 4 hrs. Actual time in the high temperature furnace is about 11 hrs. Seven hours of this interval are required to bring the castings to the required temperature, and the remaining 4 hrs. devoted to ensuring all castings reaching a uniform temperature and allowing sufficient time for absorption of the free cementite. At the end of the 4-hr. holding period in the high temperature furnace, the car containing the castings is lowered to the floor and shifted to the cooling furnace.

Test Results Obtaincd.

Air cooling during the shifting of the car and the lower temperature in the furnace brings the temperature of the castings down to 740 deg. C. (1,364 deg. Fah.) in 4 hrs. At this temperature the drawing operation begins. That temperature is held for 4 hrs., dropped to 730 deg. C. and held for 4 hrs., and then dropped to 720 deg. C. and held for 4 hrs. Then the castings are allowed to cool in air.

Physical properties obtained on castings annealed by this method are said to compare favourably with these obtained by the ordinary annealing process. Results given show a tensile strength of 56,000 lbs. (25 tons) per sq. in.; a yield point of 34,300 lbs. (15.3 tons) per sq. in., and an elongation of 15 per cent. on 2 in.

Alloys Now Cast in Great Britain.

(*Continued from page* 458.)

20 ft.-lbs.; and Brinell hardness, 90 to 110. When tested at atmospheric temperatures it shows a yield point of 10 to 12 tons per sq. in.; an ultimate tensile strength of 18 to 22 tons per sq. in.; and an elongation on 2 in. of 8 to 15 per cent.; tested at 500 deg. C., the corresponding figures are 7.6 tons, 9.6 tons, and 16.0 per cent. elongation.

Before concluding this section of the Paper, reference should be made to the *yellow metals used as solders*. Different authorities use very different compositions under this heading, as may be seen by the following compositions (Table XVII) now in use in Great Britain.

Table XVII.—*Brazing Metals.*

Cu	Zn	Pb	Name.
91	9	—	"Brazing metal."
83	17	—	" "
80	20	—	" " for copper pipes and flanges.
52	Rest	1.0 max.	"Brazing spelter."

"*Brazing Solders*" were standardised by B.E.S.A. Specification No. 263 of 1926 into two main alloys. "A" contains 53 to 55 per cent. of copper, remainder zinc, with a maximum impurity content of 0.50 per cent. "B" contains 49 to 51 per cent. copper (balance zinc), with the same maximum impurity content as "A." In both grades the Sn, Sb, As or Bi content must not exceed 0.05 per cent., whilst the Fe and Pb contents are limited to 0.15 and 0.30 per cent. respectively.

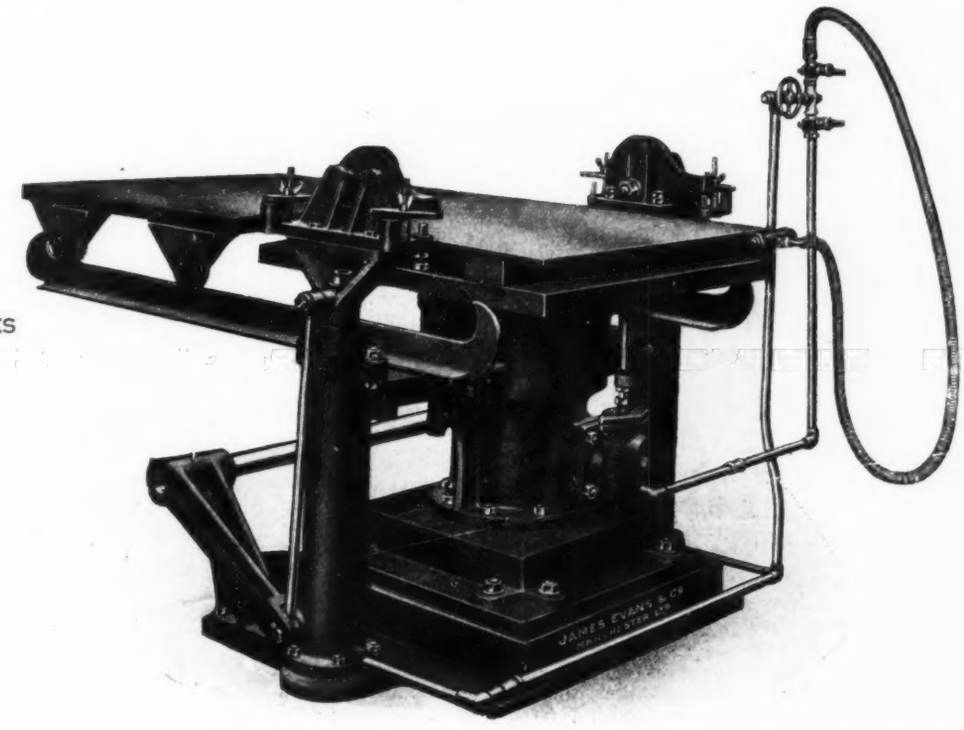
TYPE "C"

JAR RAM MOULDING MACHINE

with Turnover Pattern Plate.

For Pneumatic Power.

TWO MACHINES IN ONE.



UNSKILLED LABOUR ONLY REQUIRED.

The above machine illustrates a Jar Ram Machine with Turnover Pattern Plate which can also be used for Stripping Plate Work.

The machine has been designed to combine the two distinct features above mentioned, and is practically two machines in one, equally suitable for steel, iron, etc.

The machine as illustrated is arranged for work that requires turning over, such as steel moulding. And while the turnover arrangements are intended for general repetition work, by detaching the turnover plate from the trunnion brackets the machine can be used for stripping plate work by attaching the stripping plate to the trunnion brackets. Or, on the other hand, by removing the trunnion brackets as well, the table can be used for jolting general jobbing work.

A very important feature of the machine is the simplicity with which the intensity of the Jolt can be regulated when the operator has become accustomed to the use of the machine, which takes but an hour or so. The valves all being on the exterior of the machine are easily accessible, and there is an adjustable arrangement that will allow the jolt to be varied between 1½ in. to below ¼ in. This being done without disturbing any part of the machine.

The machine is supplied with Withdrawal Carriage, Vibrator, and Blow-off Nozzle complete. It is substantially constructed to stand heavy wear and tear, and requires a minimum amount of skill to operate.

Another important feature of the machine is in the arrangement of the hard wood anvil block for receiving the shock. The blocks being carried well down the machine in a specially designed annular chamber give considerable relief to the foundations. It also provides against the possibility of fracturing the jolting table. Pitch pine blocks are also inserted between the foundation plate and the machine bedplate to assist in the relief on the foundations, and these features considerably improve the working advantages of the machine.

IT IS ALSO ENTIRELY OF BRITISH DESIGN AND MANUFACTURE.

JAMES EVANS & CO. (M/c) LTD.

Britannia Works, BLACKFRIARS, MANCHESTER.

Foundry Purchasing—XXXVII.

By Eric N. Simons.

Checking Invoices.

Some details of the precise method of checking invoices should now be given. The first procedure is to check the invoice against the official order, examining each item to see that no error has been made. Then the order record card should be compared with it. Obviously, if any invoice has already been received for the goods concerned, the record card will show it. This should automatically preclude any possibility of duplicate payments or similar error. The invoice value should be recorded against the proper order on the order record card, thus serving as a proof that the goods have been invoiced. In some instances a large number of deliveries, and consequently a large number of invoices, may be received for a single order. This tends to crowd the record card with invoice details, but it can be avoided by allowing more space at the time of recording the order to those goods that will be delivered in several lots. By far the majority of orders are completed with one delivery.

When materials purchased have to conform to some standard specification, or have to be tested, the invoice should not be passed until the test-sheet has been examined and found satisfactory, or until the goods are definitely known to conform to the specification stipulated. Often the department for which the goods are ordered supervises the examination of goods from this point of view, and in such circumstances the signature of the departmental authority is sufficient for the checker's purposes, and comprises his warrant for assuming that the goods are technically correct. Sometimes the goods are tested, inspected, or examined, at the suppliers' works by an independent engineer. Wherever this obtains, the invoice should be withheld from payment until the official report from the inspector has been received and found favourable. This applies equally when the inspector is not independent, but an actual member of the buying firm. It is advisable to attach all such reports to the invoice or to the order-copy, so that, in case of doubt, the complete record can be turned up immediately.

Checking Invoices with Goods.

Having checked the invoice according to the office and clerical details, the next step is to check it with the goods themselves. In part, as has been indicated, this is done by the receiving departments; but a preliminary check is the "Goods Received Note," and this first check should be carried out before the invoices or their duplicates are sent to the separate departments. Any discrepancy between the amounts and weights on the "Goods Received Notes" and those on the invoice should at once be investigated. It is needless for invoices to be sent to the storekeeper for checking, since standard materials such as are received by him can usually be regarded as correct if unbroken or undamaged on receipt. His "Goods Received Note" gives the sizes, weights and quantities, and his inspection indicates speedily any loss or injury; a sight of the invoice is, therefore, unnecessary to him, since the buying department can pass it without qualms if the information supplied by the storekeeper and the weigh-office is satisfactory.

Possibilities of Error.

From time to time orders are issued without prices, this being more or less essential in every buying department, however systematically conducted. Either the goods are wanted in a hurry and there is no time to spend in asking for quotations, or the current price is unknown, and the supplier is trusted to charge the lowest possible. The invoices for goods bought without mention of a specific figure should, nevertheless, be most carefully examined to make sure that the prices charged are reasonable and explicable. Here is where the price records come in. If any alteration in basis prices, discounts, terms, and so forth, are detected, and no reason for them can be perceived, the supplier should be asked for an explanation. If the charges are confirmed, they should be noted down on the price record cards.

Another possibility that, if not carefully watched, may cause the whole system to break down, is the giving out of rush orders by telegram, telephone, or letter. Not infrequently, confirmation of these is overlooked, and the official orders are never sent. The invoices eventually come in, and because no orders can be found for them, either in the books or on the cards, correspondence is entailed or investigation necessary. Especially does the situation become complicated if the person who issued the verbal order happens to be away. No golden rule for the prevention of occurrences of this sort can be given. All hinges upon the memory and character of the person who gives out the order. He alone can remember or forget to have an official order made out. Any emergency order of this kind needs to have its resultant invoices thoroughly checked to make certain that undue advantage of the absence of a price is not taken by the supplier. Sometimes it is advisable to hold back the official order until a price can be inserted, but in general this procedure causes delay and confusion.

Where the Traffic Department can Co-operate.

Sometimes suppliers will send goods carriage forward, ignoring the printed stipulation on the official order that goods should be sent carriage paid. Possibly, in their quotation, they have overlooked the factor of carriage, and seek to evade the responsibility. It is quite possible that the checker, unless particularly careful, will omit to remark the words "Sent carriage forward" that probably appear in some out-of-the-way corner of the invoice, and will pass the document forward for payment. The carriage invoice will eventually be received by the traffic manager, who, perceiving that the invoice has been passed for payment, may assume that the charge is correct, and pay it. To obviate errors of this sort, it is advisable to have a standard rule, either that all goods should be sent carriage paid, or that they shall be sent carriage forward. Then the traffic manager can be notified of any variations or exceptions, so that when the railway charges come in, he will know whether to pass or query them. If the supplier's practice is to send all goods carriage forward, he should nevertheless be instructed to comply with the buyer's requirements, and *show any charge for carriage as a separate item on his invoices.* These charges should be submitted to the traffic department for checking.

There are several directions in which the co-operation of the traffic department in the passing of invoices is advisable, if not indispensable. For example, when serious delays have taken place in connection with goods, the supplier may put a consignment on board a passenger train to ensure quick delivery. Since passenger rates are higher than those on goods trains, he may seek to evade his responsibilities by sending the consignment carriage forward. But as the delay is entirely his own fault, there is no reason why the buyer should have to bear the extra cost of this mode of transport. Assuming that the supplier is correct in charging carriage on his goods, he should nevertheless be debited with the difference between the cost as sent by goods train and as sent by passenger train. If his order specifies carriage paid, and he is accustomed to send and supply his goods carriage paid, then he must be debited with the whole amount.

In this connection, the traffic department should be notified of all large contracts for, say, raw material (for delivery over periods of months) so that, in the case of alternative routes, terms or rebates (if in contra account) can be fixed. The railway companies are now so consolidated that every available opportunity for competitive rates and freights should be taken to prevent monopoly.

Again, if the buyer has agreed to pay carriage on a consignment of goods, there may be ways of sending it at lower rates. On points of this sort the traffic manager can give useful information, so that the order may specify the exact phraseology to be used by the supplier's clerk when consigning the material, the multiples in which goods are to be sent to ensure economical transport, the kind and amount of packing to be used to enable the goods to come under a certain classification, and so on. There should be continual co-operation and consultation between traffic department and buying-office.

Hidden Facts in Oil-Sand Practice.

(*Continued from page* 460.)

a mechanical mixer there was certainly a more efficient mixing of the binder with the sand, and stronger cores were obtained for the amount of binder used. The effect of the mechanical mixer came to the same thing as diluting with water. The taking of sea sand from the back of the shore was important. He did not think the salt content was important as far as the refractoriness was concerned. It certainly weakened the binder, as any alkali turned the oil into soap. With reference to Mr. Paulin's last question, burnt sand certainly had less gas because by the reclamation process used in America the sand was passed through a kiln and all carbon burnt out. The sand was then washed and also graded and put into bunkers. Certainly a better quality sand was obtained.

Steel and Gas Evolution.

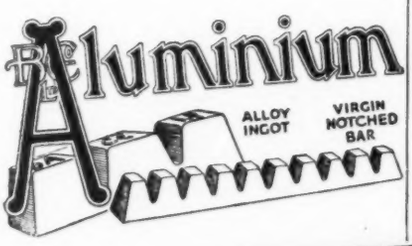
Mr. Stobie said that from the discussion he felt that he was the only one who was not surprised at the volume of gas evolved from hot sand. Taking a material such as steel, one had anything up to 200 times its own volume in gas. To get really to rock bottom one could hardly compare sands by taking them as they were received. It was necessary to make sure that all colloidal matter was removed. He had been surprised to note that, as the linseed oil increased in percentage, for each percentage of increase there seemed to be about 2 c.cs. of extra gas from the sand, which seemed to him to be out of all proportion to the total. It appeared that it was preferable to re-use the old sand, perhaps even to heat it up beforehand.

Mr. Hudson replied that, as Mr. Stobie had said, gas generated from sand was possibly from various sources, but that question would entail research. At the present time he was absolutely non-committal, and would only say that the gas was there and should be washed out. It was not absorbed during the process of baking, but was there in the first place. That meant that they would have to find out more about sands if they wanted successful castings.

Mr. Shaw proposed a vote of thanks to Mr. Hudson, which Mr. Allan seconded, and which was passed with acclamation.

Durapso: A High-Elastic-Limit Steel.—The Aciéries de Pompey in France have developed and placed on the market under the trade-name of "Durapso" a high-elastic-limit steel. Its physical properties are: Tensile strength, 50 to 60 kg. per sq. mm. (31.75 to 38.10 tons per sq. in.); elastic limit, 34 to 40 kg. per sq. mm. (21.60 to 25.40 tons per sq. in.); elongation, 24 to 30 per cent. It will bend until the two halves of the test-piece become parallel at a distance of the thickness of the test-piece. It greatly resists corrosion.

For castings which must be light in weight, capable of speedy machining and a fine finish, choose a light alloy of



CASTING ALUMINIUM

Aluminium Data Sheet
B2
Page 5

Gates, Risers and Chills.

The remedy lies primarily in keen attention to gating. The ideal to aim at in designing the gate for the incoming metal is the same with all metals. The metal should not splash or set up too great a turbulence in the mould. The metal should be so directed that when arriving at thick sections it should be at a lower temperature than the thin sections. If conceivably possible, the different sections of a casting should solidify within the same period of time.

That ideal is very seldom realized in practice, but much may be done by attention to one simple rule. Either pour direct on to a thick section, and so feed it with 'live' metal during solidification: or, gate remote from that thick section, and so ensure that the metal, when it arrives, has given up much of its heat to the walls of the mould and is on the point of solidification.

It is the illogical design and placing of gates in a manner which is neither the one nor the other of the above extremes that gives rise to trouble.

Now, although the above gives the general principle, that principle cannot be followed out in practice on more than a few castings. Therefore it is necessary to resort to risers and chills, the former to feed isolated heavy sections, the latter to ensure that heavy sections which cannot be reached by a riser solidify at the same rate as adjacent sections. Both risers and chills, used alternatively or together, are more in evidence in aluminium than in brass or iron foundries. More detailed information is available as to their design and placing, but in nine cases out of ten any founder of experience will work out his own methods satisfactorily, once he realizes that alu-

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Trade Talk.

THE COWPEN DRY DOCKS & SHIPBUILDING COMPANY, LIMITED, Blyth, launched during 1929 7,151 gross tons of new ships.

THE HUNDREDTH LOCOMOTIVE built in the London Midland & Scottish Railway works at Crewe since May was completed on Monday last week.

MESSRS. A. C. JONES & COMPANY, iron and steel merchants, have removed from 6, Bank Street to 10, Dalewood Drive, Sheffield.

G. D. PETERS, Slough, have been awarded a contract by the London Electric Railway for the supply of electric pneumatic door apparatus for passenger coaches.

THE AGRICULTURAL & GENERAL ENGINEERS, London, have received an order for an air-compressing installation for a mining and smelting company in British Columbia.

THE WELSH tinplate works will be closed during the whole of Christmas week, and the steelworks are expected to remain closed from Tuesday, December 24, until the following Sunday.

THE EMPLOYEES of Shaw Glasgow, Limited, Maryhill Ironworks, Glasgow, have contributed £283 to their Hospital Fund during this year. The allocation amongst various institutions includes £85 to the Western Infirmary.

THE METROPOLITAN CAMMELL CARRIAGE, WAGON & FINANCE COMPANY have been awarded orders by the Buenos Ayres Great Southern Railway for carriage and wagon ironwork spares for ballast wagons, etc., to the value of about £20,000.

THE MERSEY DOCKS AND HARBOUR BOARD have accepted a tender from Messrs. W. H. Allen, Sons & Company, Limited, for centrifugal pumping plant; and another for structural steelwork from the Horseley Bridge & Engineering Company, Limited.

THE EMPLOYEES of the Etna Iron & Steel Company, Limited, Motherwell, have subscribed the sum of £96 12s. to local charitable institutions. The employees of Messrs. Steven & Struthers, Kelvinhaugh, Glasgow, have given £93 to charities for 1929.

THE OUTPUT from the shipbuilding yards on the River Wear during this year totals 58 vessels of 243,924 gross tons, against 50 ships of 207,676 gross tons in 1928. Messrs. William Doxford & Sons, Limited, head the list for the river with eight vessels of 38,083 gross tons.

Two Diesel-driven oil tankers of 13,500 tons each have been ordered by Norwegian shipowners from Messrs. Swan, Hunter & Wigham Richardson, Limited, Wallsend-on-Tyne. This brings the total of Scandinavian orders recently booked by these builders to about 18.

THE GREEK steamer "Dorothea" sailed from Grangemouth this week for Gothenburg, Sweden, with 1,500 tons of carbonite or smokeless fuel. This is the first cargo to be shipped from the new installation at Glenboig belonging to the Bussey Coal Distillation Company, Limited.

AN OUTBREAK OF FIRE occurred, on December 20, in a building used as office and pattern store in the foundry of Messrs. Babcock & Wilcox, Limited, Renfrew. The firemen succeeded in preventing the fire spreading to the main pattern-shop, which stands near by, the destruction of which would have thrown a great many men out of employment.

ABOUT 450 MEN employed at the Morriston & Midland Tinplate Works, Morriston, were on strike on Monday last week. The stoppage, which concerned the mill department particularly, is said to be in the nature of a protest by the men against the use of Belgian bars. The strike is an unofficial one so far as the Iron and Steel Trades Confederation is concerned.

THE holders of over 90 per cent. of the 6 per cent. debenture stock of the Leeds Forge Company, Limited, have intimated their acceptance of the offer made by Broadway Finance & Investment, Limited, in conjunction with the Metropolitan-Cammell Carriage Wagon & Finance Company, Limited. The offer, which was £80 per £100 of stock, has therefore become effective.

MESSRS. SAUNDERS' foundry in Hudson Road, Sunderland, which has been idle since the firm went into voluntary liquidation some time ago, has been purchased by local chartered accountants on behalf of a firm, the name of which has not yet been divulged. Modern machinery is to be installed for the making of heavy castings. A start will be made early in the New Year, and when in full operation it is expected that about 300 hands will be employed.

THE IMPROVEMENT in the Aberdeen trawling industry is reflected in the number of new trawlers which are being built by local owners. The orders placed for new trawlers during the past six months have been more numerous than at any period since the war. Recently three—the "Braconbrae," "Pittstruan" and "Loch Laggan"—were launched from Aberdeen yards in a single day. It is stated that the Aberdeen fleet is now larger than that of Hull.

MESSRS. YARROW & COMPANY, LIMITED, Scotstoun, have recently obtained the following contracts:—(1) An installation of three Yarrow boilers for a power station at Bombay; (2) high-pressure land-type boilers for the Japanese Government; and (3) one large boiler for a power station in the City of London. The firm's licensees in Holland have also received orders for two large Yarrow boilers of the land type for the Nijmegen power station, this being a repeat order, and two large Yarrow boilers, land type, for the Geertruidenberg power station, which is the second repeat order for this station. The C.P.R. liner just launched on the 17th inst., the "Empress of Japan," will be supplied with Yarrow high-pressure boilers of special design.

A PLEA FOR a more intensive advertising of Scotland as an industrial country by the secretary of the Falkirk, Grangemouth and East Stirlingshire Publicity and Development Association was made recently. He contrasted the progress of Scotland with that of Germany during the post-war years, and said that there should be inaugurated a campaign for the suppression of what was termed "pernicious criticism," which was all too frequently rearing its head to the commercial detriment of Scotland. The primary needs of ocean, road and rail transport were abundantly satisfied in Scotland, and, with the available sources of energy and a plentiful supply of water, the country could meet the needs of the most enterprising manufacturers.

THE BRITISH CAN COMPANY, LIMITED, is making an issue of 186,000 7½ per cent. redeemable cumulative preference shares of £1 each at par. The company has an authorised capital of £750,000, divided into 250,000 7½ per cent. preference and 500,000 ordinary shares. It has been formed for the purpose of developing the manufacture of containers in the British Isles. For this purpose, it has agreed to acquire the business of Messrs. Ernest Taylor, Limited, of Liverpool, and has entered into agreements with two American companies in the same line of business. The directors contemplate the erection of new factories. The directors are Sir John Ferguson, M.P. (chairman), Mr. Ernest Taylor (managing director), Mr. J. H. Jackson and Mr. F. W. Rankin. Additional directors representing the American interests will join the board after allotment.

MR. W. L. HICHENS, chairman of Messrs. Cammell, Laird & Company, Limited, in an address to the students of Birkbeck College, London, recently, said that the root trouble of the basic industries in this and other countries was that their capacity was in excess of the public demand. There were too many coal mines, steelworks, and shipyards; if half were shut down, the rest might be prosperous. This over-expansion was partly due to abnormal war-time demand, but the primary cause seemed to be the economic law that supply always tended to overtake demand. The situation had been aggravated in this country by the rapid industrialisation of other countries. The facts we had to face were that our basic industries were in a stationary condition, and that there was no immediate prospect of a change. Individualism and unlimited competition had broken down in the basic industries because, while admirably adapted to the old conditions, they were unsuited to the new. Combination in the new age must take the place of isolated individualism; co-operation must succeed competition. Though the methods of rationalisation must begin at home, they must extend throughout the international industrial field in course of time.

Obituary.

MR. MAXIMILIAN MANNABERG, who was for several years vice-president of the Iron and Steel Institute, has died in London, at the age of 72 years. As a result of his activities the Iron and Steel Industrial Research Council was founded.

MR. JOHN WOOD, who was formerly a member of the firm of John Wood & Sons (Wisewood), Limited, of Wisewood Forge and Rolling Mills, Sheffield, died on December 15, at the age of 86 years. He retired from the business about 33 years ago.

Company Meeting.

Dorman, Long & Company, Limited.—In the course of his address at the annual meeting of Messrs. Dorman, Long & Company, Limited, held at Middlesbrough on December 17, SIR ARTHUR DORMAN referred to the possibility of a heavy buying movement setting in in the iron and steel trades before the completion of their next financial year. This, he said would not surprise him, in view of the fact that the world's requirements were large, and vast undertakings had been held up for many years past waiting for a return of confidence. As to the coal position generally, he was unable to say any words of encouragement in regard to the Government's coal-marketing scheme. They had acquired their collieries to obtain control of adequate supplies of fuel for their iron and steel works. Apparently, the Bill intended to apply the same restriction to coal so used as would be operative upon coal produced for the open market. They could not charge an increased price for their coal, but they would, none the less, have to bear increases in their costs arising from alterations in the hours and wages of their men. The iron and steel trade itself was subjected to severe competition, especially from the Continental makers with cheaper labour and, in many cases, cheaper materials, and it seemed to him clear that unless they were allowed to supply their own requirements of fuel from their own collieries without restriction, serious damage would be done to the iron and steel industry, with the inevitable result that output would be curtailed. As regards the coming year, the chairman said they had made a good start, and, with the exception of corrugated sheets, they had a fair order-book, particularly for shipbuilding and constructional material. Prospects were good in most departments, but they must not disguise from themselves the fact that the fear of increased taxation and of labour and financial troubles was likely to restrict business in the near future. Already the freight market was suffering, and cargo boats were being laid up. They had had the benefit of rate relief since December 1, 1928, by way of reduction of the railway rates on coal, coke, ironstone and limestone from the collieries and quarries to their works. This in itself had proved to be a substantial help, but since October 1 this year they were getting the benefit of further assistance from the reduction by three-quarters of the local rates on their iron and steel works and collieries. He was able to say that the relief to their company was proving of considerable benefit. Referring to the amalgamation of the company with Messrs. Bolckow, Vaughan & Company, Limited, Sir Arthur said the combined productive capacity was about 3,500,000 tons of coal, 2,500,000 tons of ironstone, 1,500,000 tons of pig-iron and 1,500,000 tons of steel. The chairman said they were convinced that substantial economies were likely to result.

Personal.

MR. J. LÉONARD, works manager of the Angleur-Athus Company, has been elected President of the Belgian Foundry Technical Association. The retiring president, Mr. Marcel Remy, was accorded a hearty vote of thanks for his work during the past year.

Wills.

MARSHALL, H. D., of Messrs. Marshall, Sons & Company, Limited, engineers, Gainsborough £3,414

MILLS, C. E., chairman of Messrs. Gjers, Mills & Company, Limited, Ayresome Ironworks, Middlesbrough £73,627

WEBB, J. S., of Messrs. Joseph Webb & Sons, Limited, iron and steel manufacturers, Irwell Forge, Bury £12,148

New Company.

C. H. Thompson, Limited, Booth Street, Middleton Junction, Lancaster.—Engineers, founders, etc. Directors: Mrs. E. H. Hilton, W. R. Ingoe and F. Kennedy.

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1930 MAY REDOUBLE THEIR PROSPERITY

Our Three "Rs" for the New Year are
RESEARCH : REORGANIZATION : RE-EQUIPMENT
but our motto remains the same
"SERVICE FIRST"

WE HOPE TO SERVE THE TRADE
BETTER IN 1930 THAN EVER BEFORE

Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—On the North-East Coast, as elsewhere, the current week must be regarded solely from a holiday point of view as concerns business in general and market operations alike in the iron and steel trades, in which active operations are virtually suspended. Stocktaking at the various works in the district will also have to be taken into consideration at this period of the year, and, although this process is only nominal in the case of the Tees-side industry, where the amount of iron in makers' yards has for a long time been almost negligible in quantity, statistical returns must necessarily be prepared for accountancy purposes. With regard to the outlook for the near future, it is, of course, too early to speculate with any degree of accuracy on the effects of projected legislation on the costs of production at the blast furnaces, but it is feared in iron-trade circles that the result of the new Coal Bill is almost certain to raise the cost of essential fuel, and add a further heavy burden on industrial progress. In the meantime prices remain at the fixed minimum levels of 72s. 6d. per ton for the standard No. 3 Cleveland G.M.B. quality. For No. 1 foundry iron 75s. per ton is quoted, for No. 4 foundry iron 71s. 6d., and for No. 4 forge 71s. per ton.

In the East Coast hematite trade no movement in current prices is expected until the New Year, when the quotation for mixed numbers will probably be advanced to 80s. per ton, as the basis for the home consumer, though it may be possible to shade this figure for substantial export business. On the North-West Coast Bessemer mixed numbers are quoted at 77s. to 78s. per ton at works.

LANCASHIRE.—With practically a blank week for local markets for foundry pig-iron, there is little to report on this occasion, while prices remain unchanged. Quotations are firm, with Staffordshire and Derbyshire No. 3 brands at 77s. per ton, including delivery in the Manchester price zone. Scottish iron prices are well held at up to 93s. 6d. per ton delivered.

THE MIDLANDS.—The demand for deliveries of foundry pig-iron ex-contracts is still good, and some of the furnaces cannot cope with the pressure which exists. New business, however, has been practically non-existent this week. Quotations are firm, as follow:—No. 3 Derbyshire, 78s. 6d.; No. 3 Northants, 75s.; North Staffordshire, 78s. 6d.; and Scottish brands, 95s. 6d. to 97s., all per ton delivered local stations.

SCOTLAND.—Holidays in this particular area being postponed until the New Year celebration, business has been continued as usual this week, but with little change for the better, so far as can be observed. Deliveries of pig-iron, however, continue fairly satisfactory, with quotations firmly maintained on the basis of 78s. per ton, f.o.t. furnaces, for No. 3 Scotch foundry pig-iron.

Steel.

As will be readily assumed, there is little of interest to record in this week's movements in the steel trade, markets being closed as usual during the holidays. Interest has been centred on last week's increase in finished steel prices. Sections have been increased by 5s. per ton, joists by 7s. 6d., and plates, except in South Wales and the Midlands, by 2s. 6d. There is no change in semi-products. Trade has been very dull, and no change for the better is expected before the New Year.

Metals.

Copper.—Movements in the market for warrant copper this week have been obviously restricted by holiday conditions, but quotations in the main have been steadily maintained.

Cash.—Wednesday, £68 2s. 6d. to £68 5s.; Thursday, £68 6s. 3d. to £68 7s. 6d.; Friday, £68 7s. 6d. to £68 10s.; Monday, £67 17s. 6d. to £68.

Three Months. — Wednesday, £67 5s. to £67 7s. 6d.; Thursday, £67 8s. 9d. to £67 10s.; Friday, £67 7s. 6d. to £67 10s.; Monday, £67 5s. to £67 7s. 6d.

Tin.—A striking reaction following the recent decline in prices of standard tin can be reported, a vigorous advance in quotations being recorded. The bull movement was partly inspired by anticipations that an official statement regarding restriction proposals would shortly make its appearance. This was promptly confirmed by the issue of a recommendation of the Council of the Tin Producers' Association that throughout 1930 mining operations should cease from 10 p.m. on Saturday until 6 a.m. on Monday. Further, it is suggested that all mining operations should cease for one week of seven clear days in January, 1930, also for one week or seven clear days in February, 1930, and—if it be deemed necessary—also for one week of seven clear days in March, 1930.

Official closing prices :—

Cash.—Wednesday, £182 15s. to £183; Thursday, £183 2s. 6d. to £185; Friday, £179 17s. 6d. to £180; Monday, £178 to £178 5s.

Three Months.—Wednesday, £186 to £186 2s. 6d.; Thursday, £186 7s. 6d. to £186 10s.; Friday, £183 2s. 6d. to £183 5s.; Monday, £181 2s. 6d. to £181 5s.

Spelter.—No improvement can be reported in the market for this metal, in which conditions are largely influenced by Cartel agreements of the Continental producers. Prices show little change, as seen from the following figures :—

Daily quotations are :—

Ordinary.—Wednesday, £20 3s. 9d.; Thursday, £20 5s.; Friday, £20 2s. 6d.; Monday, £20.

Lead.—The market for foreign pig lead continues quiet and uneventful, prices, however, remaining fairly steady, with only a slow demand on home consumers' account, due to seasonal causes.

The week's prices have been :—

Soft Foreign (Prompt).—Wednesday, £21 10s.; Thursday, £21 10s.; Friday, £21 10s.; Monday, £21 15s.

Value of Research in Refractories.

(*Concluded from p. 456.*)

of taking a few samples from a plant and examining these in the laboratory and perhaps, following this, examination by simulative experiments. Surely, it was better to conduct an organised research into retort design, operation and efficiency, which would necessarily include the full use of the laboratory as an instrument of research.

Mr. S. R. Hind referred to the twofold objective of the industry, viz., to continue present methods of manufacture and use at a lower cost, and to improve the products so as to increase their utility in the direction of longer life or their ability to withstand more severe conditions.

Insulation of Furnaces.

Mr. R. J. Sarjant, who deputised for Sir Robert Hadfield, in the course of his remarks emphasised the need of greater attention to the lagging of furnaces. He thought that the majority of furnace builders were now fully convinced of the value of good insulation. He was interested to find recently in the case of a furnace in Birmingham, that a gas furnace was actually working, with something like 14 in. of insulation. This was something unheard of hitherto in connection with furnace practice. It would be an advantage if something could be done to devise more expeditious methods of testing spalling. Up to the present they had found no satisfactory solution in the methods of testing spalling. The standard methods were, he thought, too long and too laborious for an organisation that had many other duties to perform, and which was not looking at the refractory problem from the same angle as the actual maker of refractories. It was a fact that as regards spalling they had, as yet, to depend upon the service conditions tests to decide the value of a material from this particular viewpoint.

As regards monolithic structures, he was of the opinion that all research must be done by the organisation itself. He was glad to be able to say that many valuable and profitable lines of work had been carried out in this connection, and he was convinced that this did not represent by any means, the least valuable aspect which could be presented by refractories research.

The Chairman said that some very interesting matters had been discussed, and it might be well worth while following these up during another session.

British Empire Trade Exhibition, Buenos Ayres, 1931.—The General Secretary (5, Parliament Mansions, Orchard Street, Victoria Street, S.W.1) has sent us a copy of a small brochure containing particulars of this, the first All-British Exhibition ever held in South America. He informs us that the Prince of Wales has expressed his willingness to become patron of the Exhibition, which is to be held in Buenos Ayres from February 18 to April 2, 1931.

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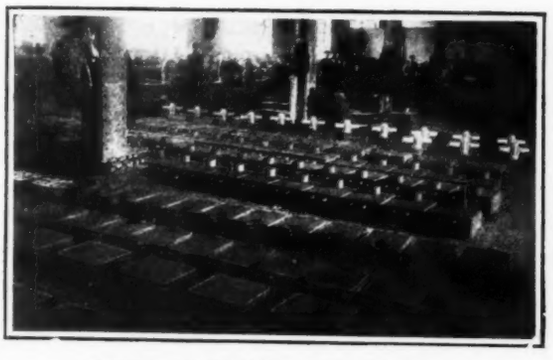

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Standard cash	67	17	6
Three months	67	5	0
Electrolytic	82	10	0
Tough	74	15	0
Best selected	75	5	0
Sheets	110	0	0
India	90	10	0
Wire bars	83	10	0
Do. Jan.	83	10	0
Do. Feb.	83	10	0
Ingot bars	83	10	0
H.C. wire rods	85	10	0
Off. av. cash, November	69	8	4 5/14
Do., 3 mths., November	68	19	3 1/14
Do., Sttlmnt., November	69	8	5 1/2
Do., Electro, November	82	19	9 1/2
Do., B.S., November	75	16	11 1/2
Do., wire bars, November	83	15	5 1/2
Aver.spot price,copper, Nov.	69	8	4 5/14
Solid drawn tubes			15d.
Brazed tubes			15d.
Wire			11½d.

BRASS.

Solid drawn tubes	12¾d.
Brazed tubes	14¾d.
Rods, drawn	12¾d.
Rods, extd. or rlld.	7¼d.
Sheets to 10 w.g.	11¼d.
Wire	10¾d.
Rolled metal	10½d.
Yellow metal rods	7½d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8½d.

TIN.

	£	s.	d.
Standard cash	178	5	0
Three months	181	2	6
English	181	0	0
Bars	183	0	0
Straits	182	17	6
Australian	182	2	6
Eastern	188	10	0
Banca	190	17	6
Off. av. cash, November	180	13	7 1/2
Do., 3 mths, November	183	12	10 1/2
Do., Sttlmt., November	180	13	9 1/2
Aver. spot, November	180	13	7 1/2

SPELTER.

Ordinary	20	0	0
Remelted	18	15	0
Hard	17	0	0
Electro 99.9	22	2	6
English	20	10	0
India	18	10	0
Zinc dust (Nom.)	31	10	0
Zinc ashes	6	10	0
Off. aver., November	21	2	0 1/2
Aver., spot, November	20	17	0 1/2

LEAD.

Soft foreign ppt.	21	15	0
English	23	5	0
Off. average, November	21	12	7 11/14
Average spot, November	21	12	5 1/2

ZINC SHEETS, &c.

Zinc sheets, English	30	0	0
Do. V.M. ex-whf.	27	15	0
Rods	34	0	0
Boiler plates	26	10	0
Battery plates	27	0	0

ANTIMONY.

Special brands, Eng.	48	15	0
Chinese	31	0	0
Crude	19	10	0

QUICKSILVER.

Quicksilver	23	0	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—			
25%	7	17	6
45/50%	11	10	0
75%	19	0	0
Ferro-vanadium—			
35/50%	12/10 lb. Va.		
Ferro-molybdenum—			
70/75% c. free	4/2 lb. Mo.		
Ferro-titanium—			
23/25% carbonless	1/- lb.		
Ferro-phosphorus, 20/25%	£16	0	0
Ferro-tungsten—			
80/85%, c. fr.	3/1½ lb.		
Tungsten metal powder—			
98/99%	3/4½ lb.		
Ferro-chrome—			
2/4% car.	£30	10	0
4/6% car.	£23	2	6
6/8% car.	£22	15	0
8/10% car.	£21	7	6
Ferro-chrome—			
Max. 2% car.	£33	15	0
Max. 1% car.	£39	5	0
Max. 0.70% car.	£41	0	0
70%, carbonless	11d. lb.		
Nickel—99% cubes, or pellets	£175	0	0
Ferro-cobalt	9/6 lb.		
Aluminium 98/99%	£95	0	0
Metallic chromium—			
96/98%	2/7 lb.		
Ferro-manganese (net)—			
76/80% loose	£12	10	0
76/80% packed	£13	10	0
76/80%, export	£13	0	0
Metallic manganese—			
94/96%, carbonless	1/4 lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0	2	0
Finished bars, 18% tungsten	£0	2	9

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel				3	7	6
Bundled steel and shrngs.	3	3	0 to	3	6	0
Mixed iron and steel	3	3	0 to	3	4	0
Heavy cast iron	2	17	6 to	2	18	6
Good machinery for foundries				3	2	6
Cleveland—						
Heavy steel				3	3	6
Steel turnings				2	16	6
Cast-iron borings				2	13	0
Heavy forge				3	15	0
W.I. piling scrap				3	10	0
Cast-iron scrap	3	2	6 to	3	6	6
Midlands—						
Ord. cast-iron scrap				3	5	0
Heavy wrought				3	17	6
Steel turnings	2	2	6 to	2	5	0
Scotland—						
Heavy steel				3	10	0
Cast-iron borings				2	12	6
Wrought-iron piling				3	19	0
Heavy machinery				3	9	0

London—Merchants' buying prices delivered yard.

Copper (clean)	61	0	0
Brass	43	0	0
Lead (less usual draft)	19	0	0
Tea lead	15	0	0
Zinc	13	10	0
New aluminium cuttings	65	0	0
Braziery copper	57	0	0
Gunmetal	54	0	0
Hollow pewter	132	0	0
Shaped black pewter	98	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	75/-
Foundry No. 3	72/6
Foundry No. 4	71/6
Forge No. 4	71/-
Hematite No. 1	79/6
Hematite M/Nos.	79/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	86/-
,, d/d Birm.	93/6
Midlands—	
Staffs. common*	—
,, No. 4 forge*	74/6
,, No. 3 fdry.*	78/6
Shrops. basic	—
,, Cold blast, ord.	—
,, ,, roll iron	—
Northants forge*	71/-
,, fdry. No. 3*	75/-
Derbyshire forge*	74/6
,, fdry. No. 3*	78/6
,, basic*	—

*d/d Black Country dist.

Scotland—	
Foundry No. 1	80/6
,, No. 3	78/-
Hem. M/Nos.	81/-
Sheffield (d/d district)—	
Derby forge	69/6
,, fdry. No. 3	73/6
Lincs. forge.	72/-
,, fdry No. 3	76/-
E.C. hematite	88/6
W.C. hematite	90/-
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3	—
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	77/-
Northants foundry No. 3	—
Dalzell, No. 3 (special)	105/- to 107/6
Summerlee, No. 3	95/-
Glengarnock, No. 3	—
Gartsherrie, No. 3	95/-
Monkland, No. 3	95/-
Shotts, No. 3	95/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.) nom.				10	15	0
Nut and bolt iron	9	0	0 to	9	7	6
Hoops				11	0	0
Marked bars (Staffs) f.o.t.				12	10	0
Gas strip				11	0	0
Bolts and nuts, ¾ in. × 4 in.				15	5	0
Steel—						
Ship plates	8	15	0 to	8	17	6
Boiler plts.	9	12	6 to	10	10	0
Chequer plts.				10	12	6
Angles				8	7	6
Tees				9	7	6
Joists				8	10	0
Rounds and squares, 3 in. to 5½ in.				9	7	6
Rounds under 3 in. to ¾ in. (Untested)				8	2	6

and upwards

Flats—8 in. wide and over	8	12	6
,, under 8 in. and over 5 in.	8	17	6
Rails, heavy	8	10	0
Fishplates	12	10	0
Hoops (Staffs)	9	15	0
Black sheets, 24 g.	9 17 6 to 10	5	0
Galv.cor.shts., 24g.	12 10 0 to 12	12	6
Galv. fencing wire, 8g. plain	12	0	0
Billets, soft	6 2 6 to 6	12	6
Billets, hard	7 10 0 to 8	0	0
Sheet bars	5 17 6 to 6	5	0
Tin bars	5 17 6 to 6	5	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1/4
Sheet to 10 w.g.	1/5
Wire	1/6
Rods	1/5
Tubes	1/9½
Castings	1/4

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	10d. to 1/4
Rolled—	
To 9 in. wide	1/4 to 1/10
To 12 in. wide	1/4½ to 1/10½
To 15 in. wide	1/4½ to 1/10½
To 18 in. wide	1/5 to 1/11
To 21 in. wide	1/5½ to 1/11½
To 25 in. wide	1/6 to 2/-
Ingots for spoons and forks	10d. to 1/6½
Ingots rolled to spoon size	1/1 to 1/9½
Wire round—	
3/0 to 10 G.	1/7½ to 2/2½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	21.26
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic	20.26
Bessemer	20.76
Malleable	20.76
Grey forge	19.76
Ferro-mang. 80% d/d	105.00
O.-h. rails, h'y at mill	43.00
Bessemer billets	35.00
O.-h. billets	35.00
O.-h. sheet bars	35.00
Wire rods	40.00
	Cents
Iron bars, Phila.	2.12
Steel bars	1.90
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.85
Skelp, sheared steel	1.85
Steel hoops	2.20
Sheets, black, No. 24	2.75
Sheets, galv., No. 24	3.40
Sheets, blue an'l'd, No. 13	2.35
Wire nails	2.40
Plain wire	2.40
Barbed wire, galv.	3.05
Tinplates, 100-lb. box	$5.35

COKE (at ovens).

Welsh foundry	32/6 to 35/-
,, furnace	27/6 to 32/6
Durham and Northumberland—	
,, foundry	22/6
,, furnace	20/6
Midlands, foundry	—
,, furnace	21/6 and up

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 box		18/9
,,	28×20 ,,		38/-
,,	20×10 ,,		27/6
,,	18¾×14 ,,		19/6
C.W.	20×14 ,,		16/-
,,	28×20 ,,		34/-
,,	20×10 ,,		22/7½
,,	18¾×14 ,,		16/-
Terneplates	28×20		33/6 per box basis f.o.b.

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6	0	0	to	£7	10 0
Bars, hammered, basis	£17	10	0 to	£18	10	0
Bars and nail-rods, rolled, basis	£15	15	0 to	£16	15	0
Blooms	£10	0	0 to	£12	0	0
Keg steel	£32	0	0 to	£33	0	0
Faggot steel	£20	0	0 to	£24	0	0
Bars and rods dead soft, steel	£11	0	0 to	£14	0	0

All per English ton, f.o.b. Gothenburg.

TUBES AND FITTINGS.

Over ½ in. up to 6 in.

	Tubes.	*Fittings.*
Gas ..	65%	47½%
Water ..	61½%	42½%
Steam ..	57½%	37½%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
Dec. 18 ..		68	2	6	dec.	7/6
„ 19 ..		68	6	3	inc.	3/9
„ 20 ..		68	7	6	„	1/3
„ 23 ..		67	17	6	dec.	10/–

Electrolytic Copper.

		£	s.	d.		
Dec. 18 ..		82	12	6	inc.	2/6
„ 19 ..		82	12	6	No	change
„ 20 ..		82	12	6	„	„
„ 23 ..		82	10	0	dec.	2/6

Standard Tin (cash).

		£	s.	d.		
Dec. 18 ..		182	15	0	dec.	65/–
„ 19 ..		183	2	6	inc.	7/6
„ 20 ..		179	17	6	dec.	65/–
„ 23 ..		178	5	0	„	32/6

Tin (English ingots).

		£	s.	d.		
Dec. 18 ..		183	15	0	dec.	60/–
„ 19 ..		184	5	0	inc.	10/–
„ 20 ..		181	0	0	dec.	65/–
„ 23 ..		181	0	0	No	change

Zinc Sheets (English).

		£	s.	d.		
Dec. 18 ..		30	0	0	No	change
„ 19 ..		30	0	0	„	„
„ 20 ..		30	0	0	„	„
„ 23 ..		30	0	0	„	„

Spelter (ordinary).

		£	s.	d.		
Dec. 18 ..		20	3	9	inc.	2/6
„ 19 ..		20	5	0	..	1/3
„ 20 ..		20	2	6	dec.	2/6
„ 23 ..		20	0	0	„	2/6

Lead (English).

		£	s.	d.		
Dec. 18 ..		22	15	0	No	change
„ 19 ..		23	0	0	inc.	5/–
„ 20 ..		23	5	0	„	5/–
„ 23 ..		23	5	0	No	change

AVERAGE MONTHLY PRICES OF STEEL SHIP PLATES (NORTH OF ENGLAND).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1896	5 0 0	5 0 0	5 2 6	5 2 6	5 2 6	5 0 0	5 0 0	5 0 0	5 0 0	5 2 6	5 10 0	5 10 0	5 2 6
1897	5 10 0	5 10 0	5 10 0	5 7 6	5 2 6	5 2 6	5 0 0	5 0 0	5 0 0	5 0 0	5 7 6	5 10 0	5 5 5
1898	5 10 0	5 8 9	5 8 9	5 10 0	5 16 3	5 18 9	5 17 6	6 0 0	6 2 6	6 5 0	6 10 0	6 15 0	5 18 6½
1899	6 15 0	7 0 0	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 12 6	7 12 6	7 12 6	7 12 6	8 0 0	7 6 5½
1900	8 0 0	8 0 0	8 2 6	8 5 0	8 7 6	8 7 6	8 7 6	8 0 0	8 0 0	8 0 0	7 10 0	7 0 0	8 0 0
1901	6 15 0	6 15 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 5 0	6 7 6	6 5 0	6 0 0	6 0 0	6 4 4
1902	5 17 6	5 12 6	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 10 0	5 14 7½
1903	5 10 0	5 10 0	5 15 0	6 0 0	6 0 0	6 0 0	5 12 0	5 12 6	5 12 6	5 12 6	5 12 6	5 10 0	5 13 11
1904	5 7 6	5 10 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 11 10
1905	5 15 0	5 17 6	5 17 6	5 17 6	5 17 6	5 17 6	5 17 6	5 17 6	6 0 0	6 10 0	7 0 0	7 0 0	6 2 3½
1906	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 10 0	7 0 10½
1907	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 0 0	7 0 0	7 8 4
1908	6 10 0	6 10 0	6 10 0	6 5 0	6 5 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 3 9
1909	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	5 15 0	5 15 0	5 15 0	6 0 0	6 0 0	6 0 0	6 0 0	5 18 9
1910	6 5 0	6 5 0	6 7 6	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 2
1911	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 18 4	6 15 3½
1912	7 3 9	7 5 0	7 5 0	7 12 6	7 15 0	7 15 0	7 15 0	8 0 0	8 0 0	8 0 0	8 2 0	8 5 0	7 14 10
1913	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	7 19 0	7 15 0	7 3 0	6 15 0	6 10 0	7 16 5½
1914	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 0 0	6 0 0	7 0 0	7 5 0	7 5 0	7 6 3	7 10 0	6 14 8½
1915	8 0 0	8 10 0	9 0 0	9 10 0	9 10 0	10 0 0	10 0 0	10 0 0	10 0 0	10 0 0	10 5 0	11 0 0	9 12 11
1916	11 7 6	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 9 2
1917	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0
1918	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0
1919	11 10 0	14 0 0	14 0 0	14 0 0	17 0 0	17 7 6	17 15 0	18 5 0	18 5 0	18 5 0	19 12 6	21 5 0	16 15 5
1920	22 10 0	23 10 0	23 10 0	23 10 0	23 10 0	23 10 0	23 10 0	23 10 0	24 0 0	24 10 0	24 5 0	24 5 0	23 13 4
1921	23 5 0	22 10 0	20 4 0	19 0 0	19 0 0	17 0 0	15 0 0	14 15 0	13 12 0	12 5 0	10 10 0	10 10 0	16 9 3
1922	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 4 0	10 0 0	9 7 6	9 4 0	9 5 0	9 5 0	9 5 0	9 18 4½
1923	9 7 6	9 15 0	10 5 0	10 10 0	10 10 0	10 10 0	9 18 9	9 17 6	9 17 6	9 17 6	9 18 6	10 6 10½	10 1 2½
1924	10 1 6	9 18 1½	9 17 6	9 17 6	9 17 6	9 19 4½	10 5 0	10 5 0	10 5 0	9 19 0	9 15 0	9 15 0	9 19 7½
1925	9 14 0	9 10 0	9 10 0	9 1 3	9 0 0	9 0 0	8 17 0	8 13 1½	8 7 6	8 5 6	7 16 3	7 14 3	8 15 8½
1926	7 12 2½	7 12 6	7 12 6	7 14 4½	7 15 0	7 16 10½	8 2 6	8 2 6	8 4 0	8 12 6	8 12 6	8 16 3	8 1 1½
1927	8 17 6	8 17 6	8 11 6	8 7 6	8 6 3	8 5 0	8 5 0	8 3 9	8 2 6	8 2 6	8 5 0	8 5 0	8 7 5
1928	8 2 6	8 5 0	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 6 10½
1929	8 7 6	8 7 6	8 7 6	8 7 6	8 10 6	8 12 6	8 12 6	8 12 6	8 12 6	8 12 6	8 12 6	—	—

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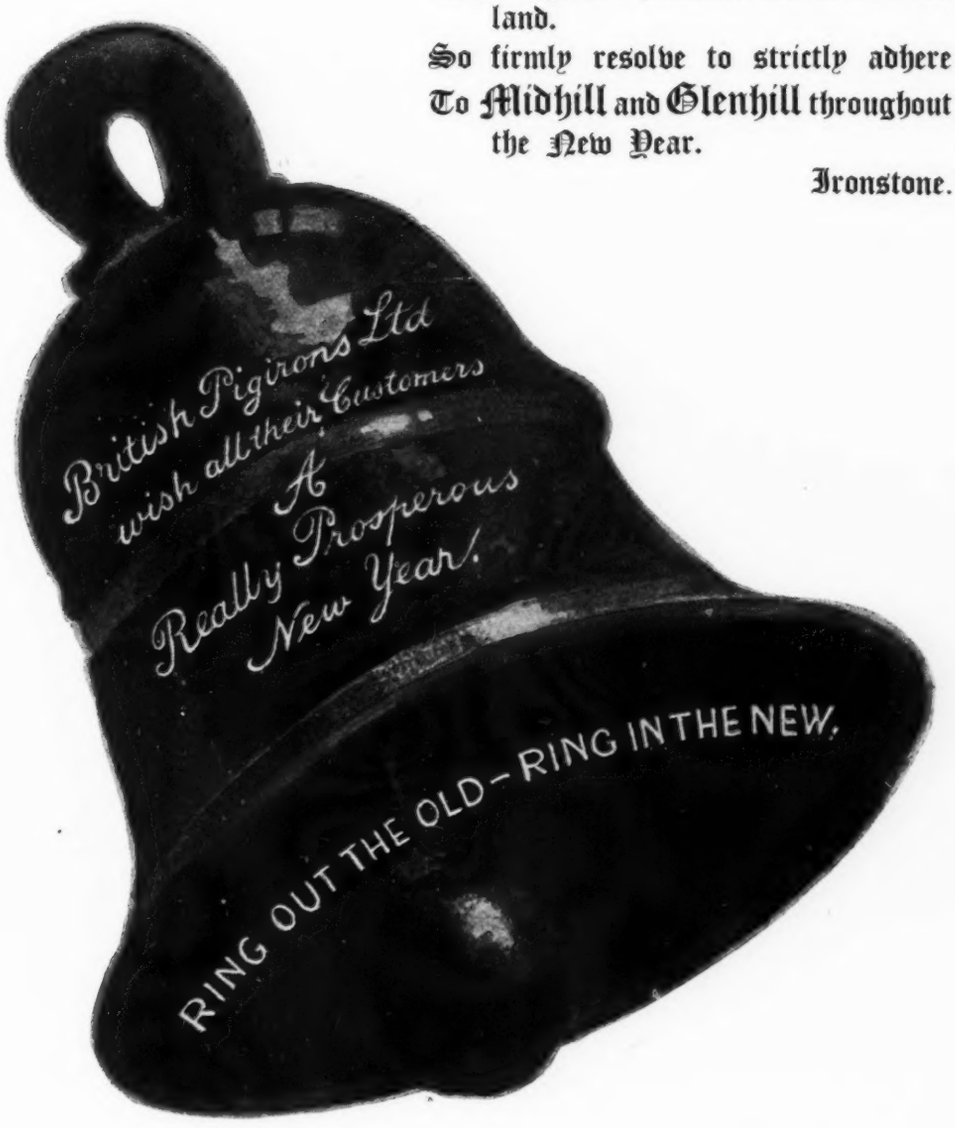

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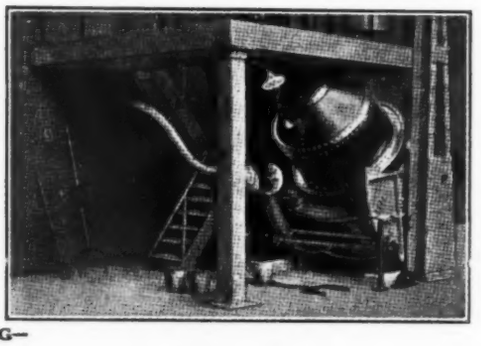

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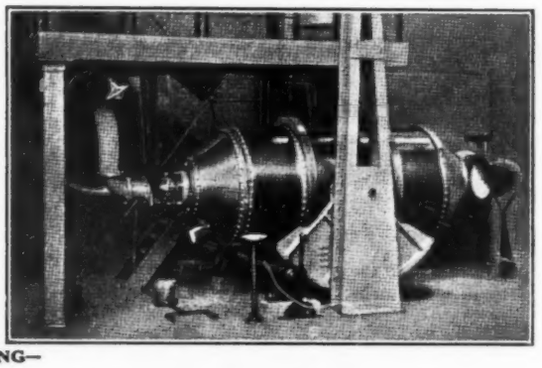

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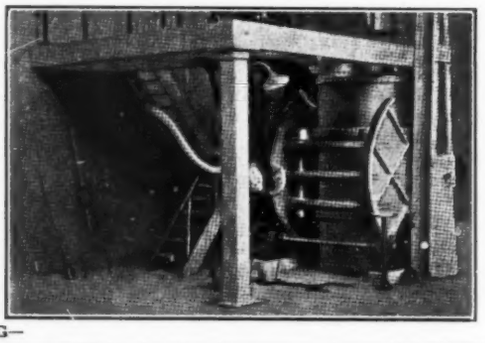

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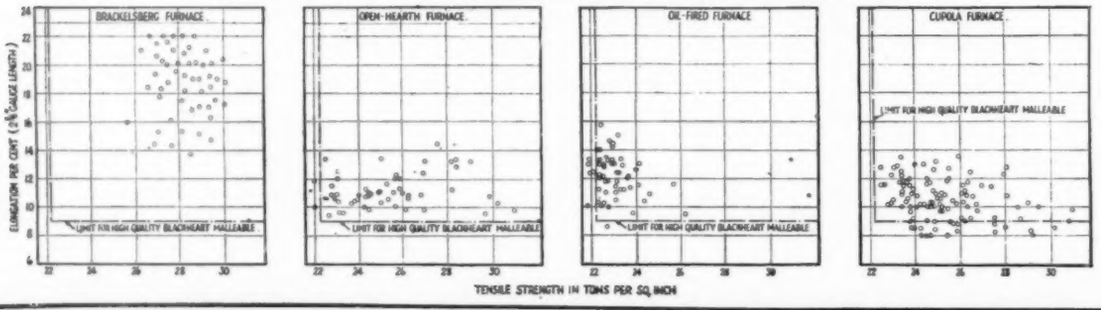

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Advantages :

Immunity from Sparks and Grit.

Avoids damage to Roofs, choking up of Gutters.

Prevents danger of Fire.

Important Labour Saver.

Conducts all Grit and Dust down to or through the Charging Platform, where they can be dropped into a cart without handling.

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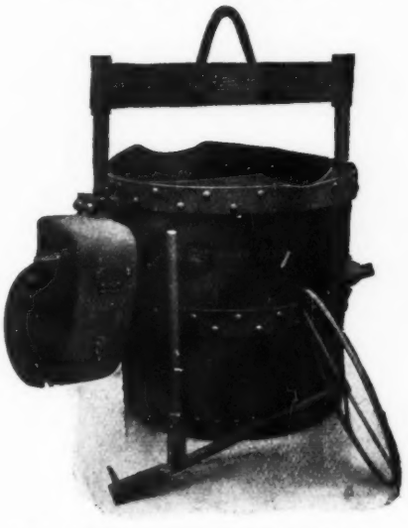
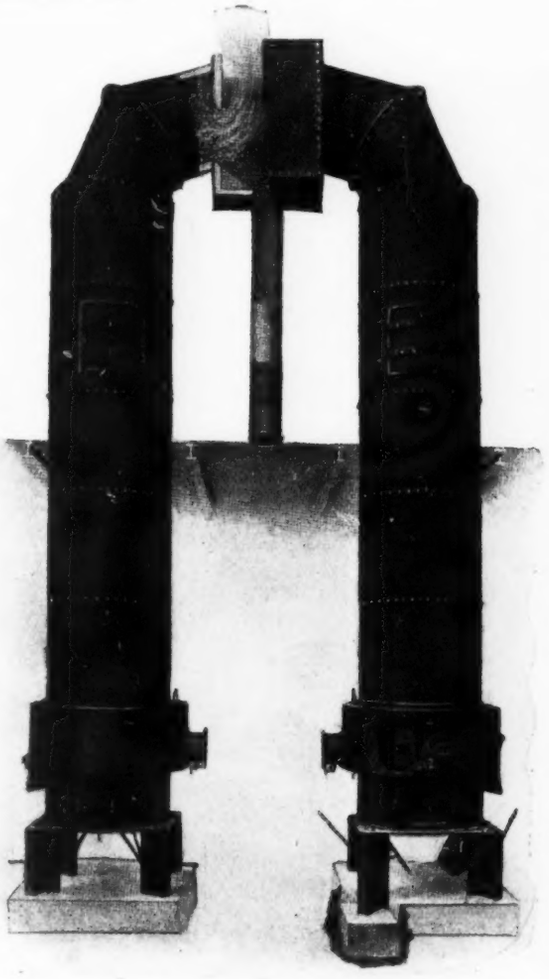
This illustration represents Geared Ladles up to 2 tons capacity.



This illustration represents Geared Ladles from 2¼ to 10 tons capacity, fitted with oil-tight gear cover.



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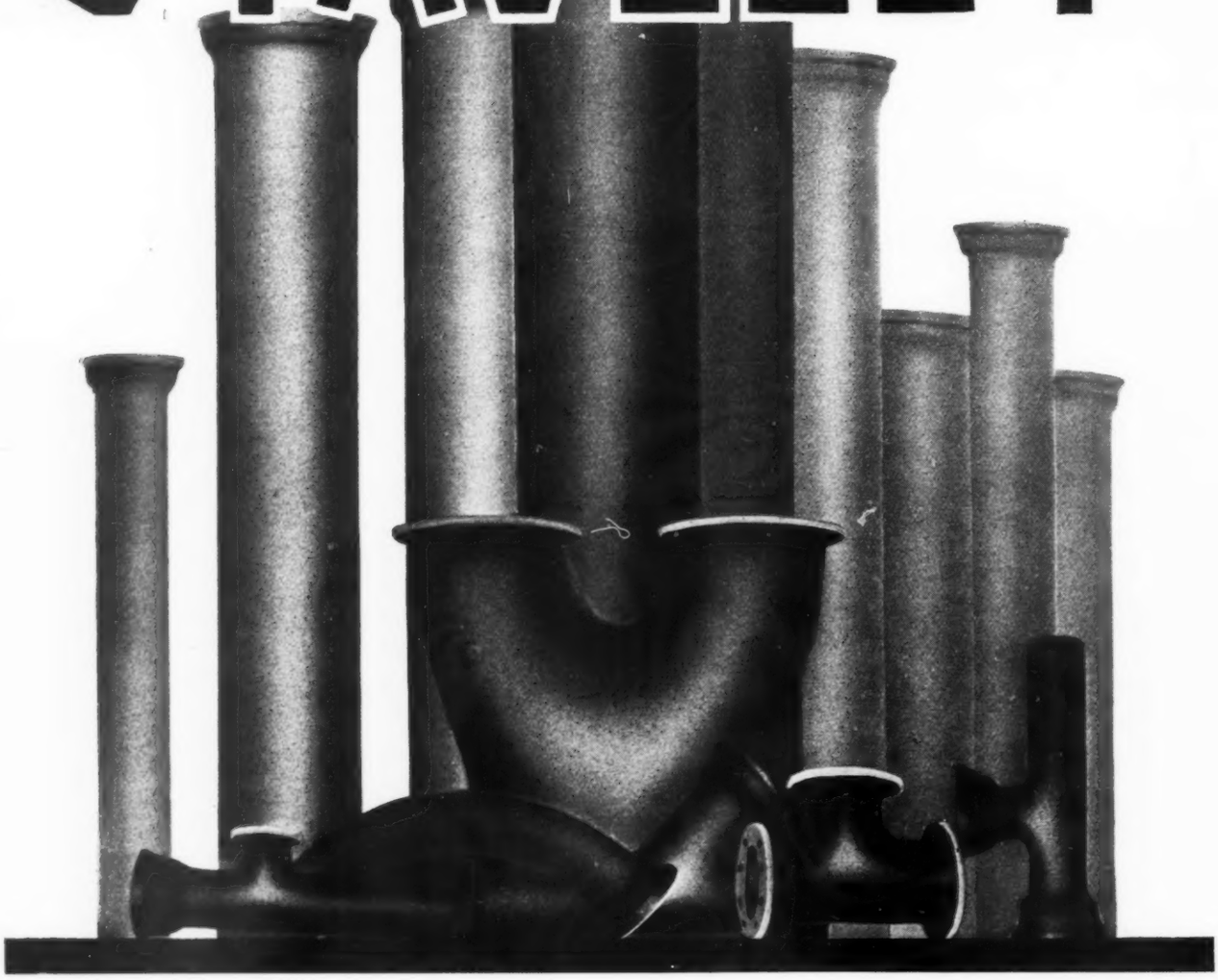

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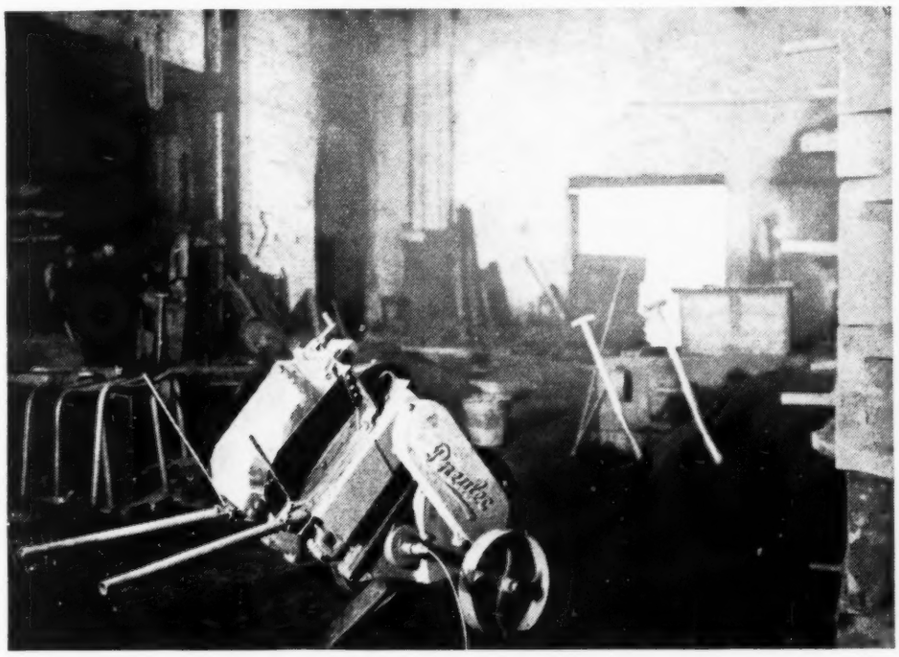

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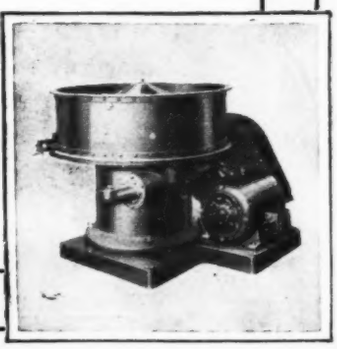

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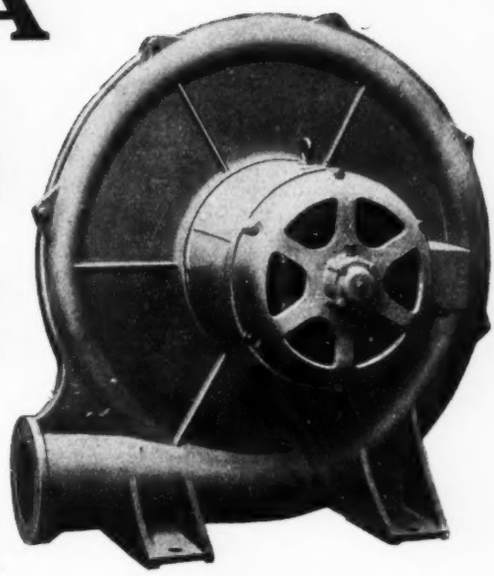

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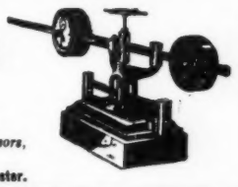

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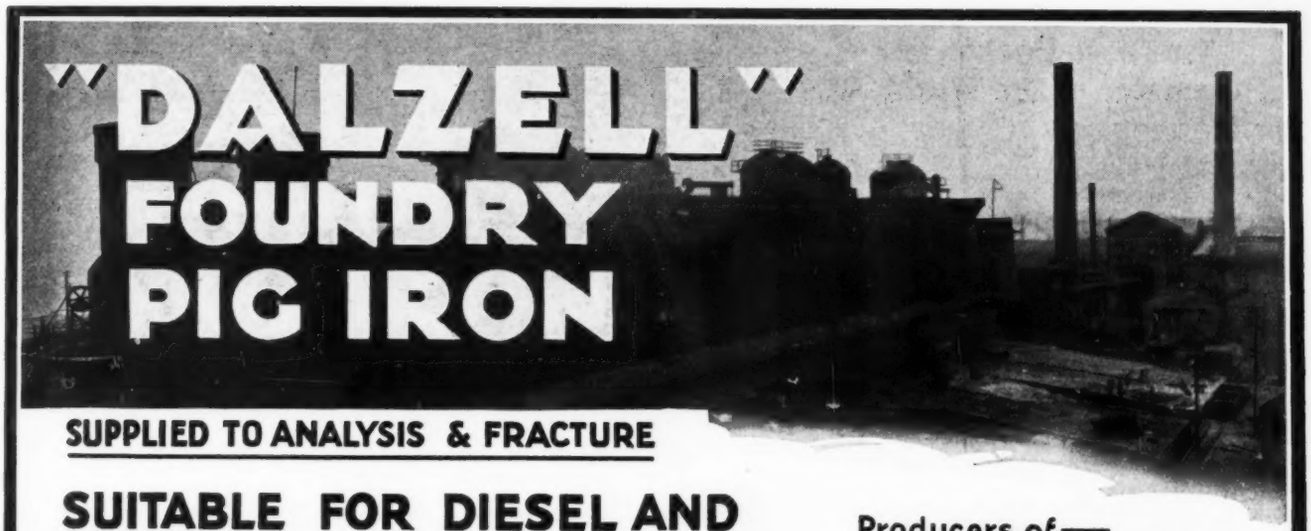

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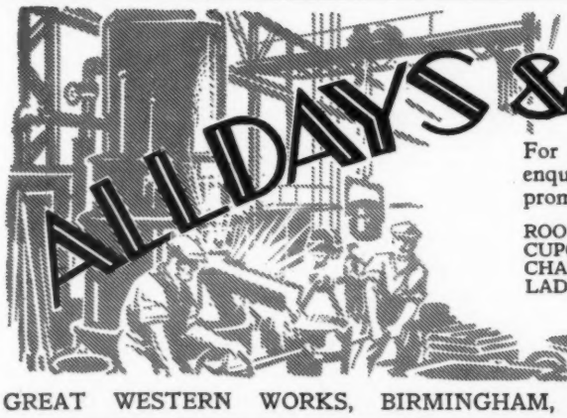

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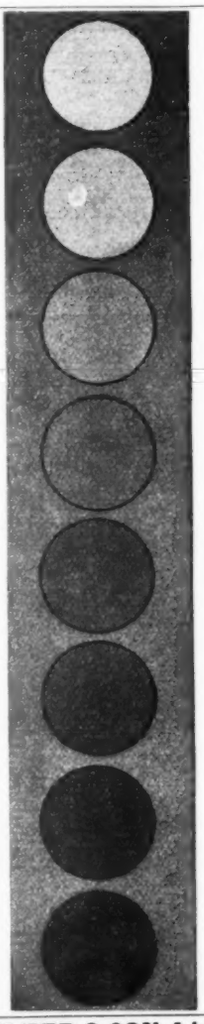

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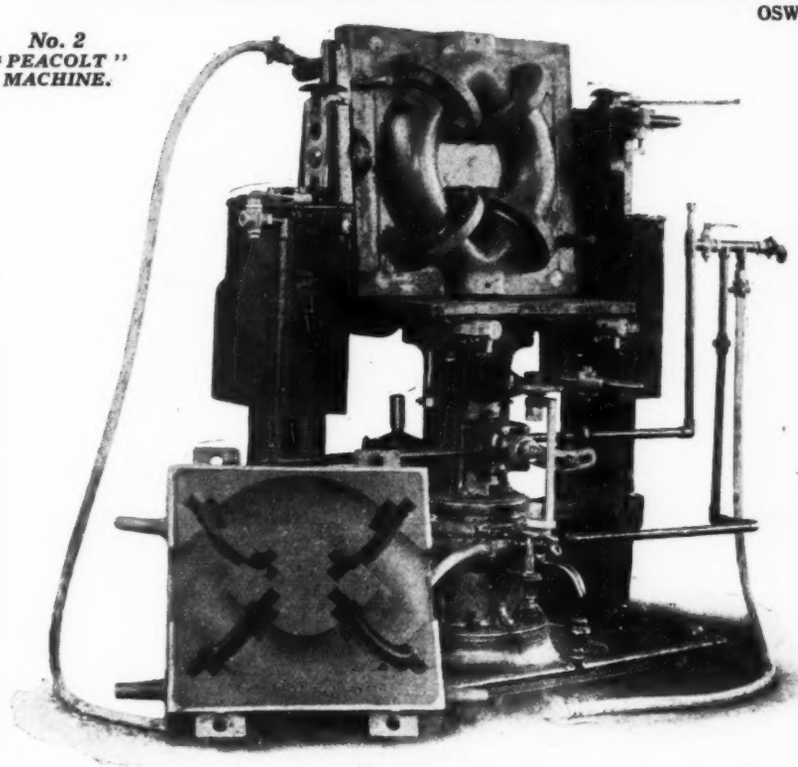

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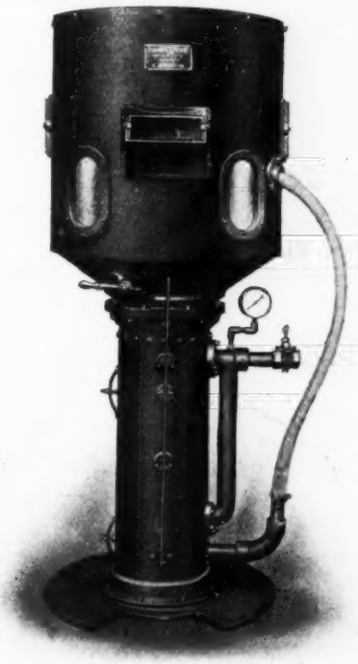

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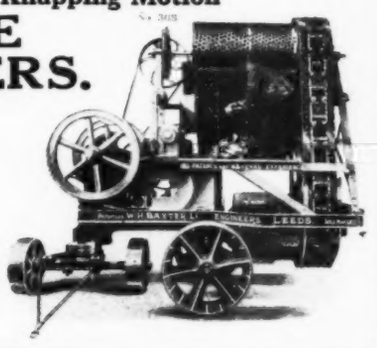

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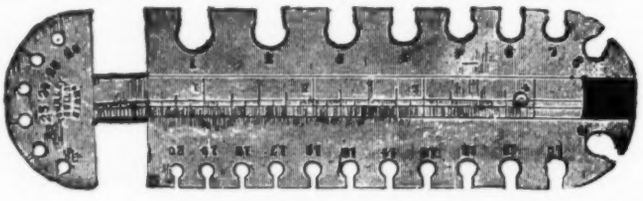

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